Growth and Physical Changes During Adolescence among Bhil Boys of Rajasthan

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PREFACE

Great areas of ignorance about the detailed aspects of human physical growth and development are remained open for the progress of future research. In India, meaningful planned studies on this aspect are of immediate inportance because of their applied value and national significance. These studies or surveys are needed especially in a developing country like India where there are innumerable ethnic groups with wide range of genetic variation, socio-economic and cultural differences. The present study, 'Adolescent growth and physical changes among Bhil boys of Rajasthan', has been undertaken in view of the above reasons with the following special features.

1 That, the study is first of its kind in the country where much attention is given for understanding the particular phase of human growth curve namely 'adolescence' by controlling the factors like, ethnicity, culture, social class and nutrition.

2 first such major study on any tribal group of India.

3 first in the series to link up nutrition for evaluation of growth in children.

4 the only study where large samples (100 in each age group) considered for any ethnic group, and

5 the only study which has been subjected to large number of body measurements to understand the patterns of growth in wider context and meaningful grouping of growth characteristics.

This project report is the outcome of my research investigation conducted during 1978-80 at the Anthropological Survey of India, Western Region, Udaipur. I am grateful to the Director, Anthropological Survey of India, for the grant of the project and providing me with all necessary facilities. I am also thankful to him for his kind permission to utilise the data of this project for my doctoral thesis. I wish to express my sincere thanks to Dr. A. K. Danda, Dr. B.B. Goswami, Dr. P.K. Misra, Dr. R. S. Mann and Dr. B. R. Ghosh of Anthropological Survey of India who at times have shown keen interest in my work and rendered all possible help towards successful completion of this study.

I am grateful to Prof. D.P. Mukherjee, former Deputy Director, Anthropological Survey of India, Calcutta, for his guidance, advice and encouragemcnt. Special thanks are due to Sri Kamal Kant Bagai, Anthropologist, Anthropological Survey of India, Mysore, for his keen supervision of this project work at the Regional Office, Western Region, Udaipur. Last but not least, I am also thankful to Sri P. K Bhaskaran, and Sri W. M. Kale for their active co-operation in tracing and making photostat copies of the figures.

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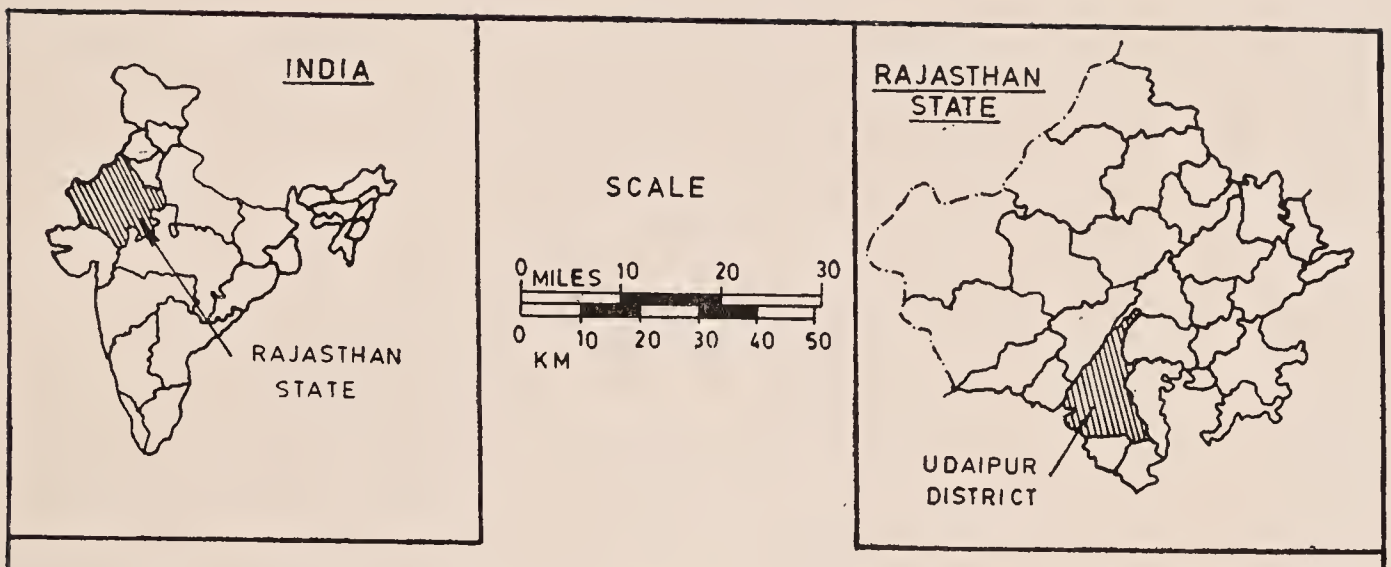

FIG. 1

AREA OF STUDY

UDAIPUR DISTRICT OF RAJASTHAN

SECTION ONE

INTRODUCTION

Growth studies are important as they provide valuable information on the status of health of the community and thus of nation's progress in the field of health and education. India with 70 crores of population constitute an amalgamation of various ethnic groups with different socio-economic levels. It has been emphasised that individual growth standards for each endogamous population are required because of the genetic determination of growth patterns (Tanner 1977) and their modification by particular environment and nutritional habits of such populations (Roberts 1960 ; Prader *et al.* 1963 ; Parsons, 1965 ; Tanner, 1966 ; Garn and Rohamann 1966 ; Hiernaux 1968 ; Birkbeck 1973). Thus growth studies have an important place in the study of individual differences in form and shape.

Studies on growth have been initiated in India rather recently (Singh Raghbir 1968 ; Singh Lakhmir 1969 ; Sharma 1963, 1970; Singh and Lakhbir 1970 ; ICMR Tech. Report, 1972 ; Malik & Singh 1978 ; and Kaul 1971). A section of the Indian population which constitute scheduled tribes having a population of about 38,015,162 (Census 1971) have not been so far studied at all from this point of view though several welfare programmes have been launched among these backward populations since independence of India in 1947. There are about 450 tribal groups distributed in different parts of India. They have different ethno-genetical, ecological and socio-economic backgrounds between themselves and from the rest of the rural and urban populations. It is necessary to establish growth standards for each of these populations not only for assessment of the present status of health and nutrition but also to use them as criteria for assessment of the socio-economic disparity between different sections of the Indian populations. Thus, growth data from these populations will be useful for theoretical understanding of the genetic variation in growth patterns because these traditionally isolated populations display a wider range of genetic diversity than the rest of the Indian populations.

The present study of adolescent growth, physical changes and nutrition is part of the said programme and purports to discuss the physical growth of a tribal community, the Bhils, the numerically largest tribe in India. The study also helps to establish standards of growth with

emperical assessment of nutritional status during this period of life and to provide baseline information on the growth and development of normal Bhil boys.

Adolescence has a special significance in the study of human growth since extrauterine growth in terms of velocity accelerates only during the first half of the adolescent period (Heald *et al*, 1969). This is the period of maximal increment and development (physical change) of the body. It is during adolescence that most adult differences in morphology, composition and performance have their genesis (Malina 1974). Furthermore, adolescence is relatively a new phase of growth wherin hormones from the gonads and the adrenal combine with growth hormone to produce the adolescent spurt (Tanner 1977). Growth differences in the early part of adolescence directly reflect the differences of environmental influence on growth. On the other hand, if physical comparisons involve successive ages of adolescence the true ethnic differences may very well manifest themselves because of growing role of hereditary factors (Francis *et al.*, 1976).

SECTION TWO

MATERIAL AND METHODS

The material utilized for the present study and the methods employed are outlined in this chapter. This includes the background information about the people studies, the nature of the sample, bodily measurements considered, rating of physical changes and assessment of nutrition as well as the design of statistical analyses and different methods of approach to the growth and development adopted in this study.

The Population

The Bhil, the numericaly largest tribe group in India having a population of about four millions, are spread over a wide geographical area in the western and central parts of the country namely, Rajasthan, Gujarat, Maharashtra and Madhya Pradesh. According to 1971 census, the population of Bhils in Rajasthan was 14,37,937. In Udaipur district alone where the study was conducted their numerical strength was 3,15,911 (Census, 1971).

Selection of Sample

As standards of growth are designed to be developed for Bhil boys, it is felt necessary to formulate these standards on a sample that face the best available environment within the population. Garn (1958) emphasises that children from different geographical regions, various social classes and different ethnic groups should not be included in a growth study because of the extreme genetic diversity of the populations and disparities of socio-economic conditions. He suggests the inclusion of genetically uniform subjects and controlling of nutrition by limiting the study to a particular socio-economic group. This might help in bringing out the sharpness of changing rates and patterns of growth even from a cross-sectional study. Tanner (1973) is also of the same opinion that in countries where the population is not genetically homogeneous, social class and ethnic origin are related and malnutrition is rampant, standards should not be constructed from a random sample of the population. But it should be based on a sample of the population that is environmentally facing the best, since these individuals represent the currently attainable range of desired norms for the population as a whole. He also suggests to have standards separately for each ethnic group. Since Bhils are a large population spread over a wide

geographical area and display a wide range of variability, it has been necessary to select the economically and culturally most advanced section of this population, for the purpose of the present study.

From these points of view the study population refers to the Bhil of Udaipur district particularly Kherwara and Sarada regions (Fig. 1) because Bhils in this area are economically and culturally more advanced than the rest of the Bhils living else where. It was verified before taking up the field investigation that the school enrolment rates of the Bhil boys were highest in these two sub-divisions. Their main occupation is agriculture. But most of the educated Bhils from this area are employed in Defence and Home departments, like, Military, Border Security Forces, Central Reserve Police, State Police Department, Mewar Bhil Corps and other organisations.

Ethnicity, Ethnohistory and Social Change of Bhils

Risley (1915) classified Bhils within the Dravidian type while Guha (1937) suggested a definite 'negreto strain' among them. They are described as having an average medium stature, dark brown skin colour, wavy to curly hair and brown or dark brown eyes. Later workers such as Fuchs (1941) and Majumdar (1944) differ from these earlier workers. They suggest that Bhils are neither Dravidians nor Aryan in their ethnic affinities. In view of their resemblance with the Mundari tribes in basic cultural traits including traces of Mundari words, history of state formation and also in genetic characters like dermatoglyphic features (Mukherjee and Chakravarti, 1964) and blood groups (Sarkar, 1954), the Bhils are suggested to have closer Mundari ethnic affinities rather than affinities with the Dravidian speaking Australoid tribes. Grierson (1927) observes that the Bhil language shows traces of non-Aryan words and their original language might have been akin to Mundri. Whatever may be the controversy about their genetic affinities, the Bhil of Udaipur, Rajasthan represent a distinct ethnic population.

The earlier mention of Bhil culture is found in the epics which refer to Bhils as a forest people. In the '*puranic*' literature they are described as a people of lower status who are famous archers. Recorded history tells mainly about the Bhils of Rajasthan. The following historical landmarks of this tribe can be built up by piecing together the fragments of evidence. (1) Presence of Bhil kingdoms about 1300 to 1500 years ago, which is a clue to their cultural affinities with the Munda group of people. (2) Annexation of the Bhil kingdoms by the Rajputs. (3) Bhils are described as 'Plunderers, thieves and law breakers (*cf*, Doshi 1974). (4) The arrival of British Raj on the scene. (5) The

Bhils have become settled agriculturists during the last century.

In 1840 the then British Government of India raised an army called 'The Mewar Bhil Corps' manned entirely by the Bhils, in order to channelise the violent urges of this martial tribe and to neutralise the perpetual unrest in the southern and western parts of the province. Since 1947 the Mewar Bhil Corps, still retaining its original name, has become a part of the Rajasthan Police Force.

Different missionary societies such as the Canadian Protestant Mission and the Catholic Mission have been working in the Bhil areas of, Rajasthan since 1899. They did social service, provided medical aid and spread education among the Bhils while propagating the Christian faith. These societies have their own schools, hostels and dispensaries for the Bhils which have played important roles as change agents leading to modernization of the local Bhils to some extent.

Size, Distribution and Method

The data for the present study were collected from 900 male individuals of Bhil parentage spread over nine yearly age groups from 11+ to 19+ years. The subjects were selected by purposive sampling technique from different schools and villages of Kherwara and Sarada subdivisions in Udaipur district of Rajasthan. The data for boys from 11+ to 17+ years and few of those of 18+ and 19+ years were collected from primary, middle, secondary and higher secondary schools (table 1). The rest of the boys studied in the age groups of 18+ and 19+ years were those who had completed school education in one of the schools as mentioned (Table 1) but were investigated in their respective villages. All the boys chosen for the study belong to families having an average annual income between Rs. 3,500/- to 5,500/- only (Table 2). Data were collected during October, 1978 to January, 1979.

Assessment of Age

Considerable difficulty has always been encountered inobtaining correct age of Indian children and more so of tribal children. In a study of this nature, assessment of age is obligatory (Sharma 1970). Considerable care has been taken for minimising errors in estimating the dates of birth, since correct age is extremely important in growth studies. Dates of birth of the subjects are derived from birth certificates which are required for admission into the schools. In Rajasthan, some local primary school teachers have been given the task of maintaining birth and death registers of their villages and sometimes of nearby

Table 1 : Sample size and its distribution by place and school

Place	School	No. of subjects
Rikhab Deo	Higher Sec. School	134
Kherwara	Higher Sec. School	296
Parsad	Secondary School	48
Kalyanpur	Secondary School	65
Sarada	Secondary School	36
Masaroom-ki-oberi	Middle School	30
Rikhab Deo	Middle School	14
Kherwara	Middle School	15
Delana	Middle School	45
Pandyawada	Middle School	36
Kalighati	Middle School	30
Kagdar	Primary School	41
Parsad	Primary School	9
Bichchiwara	Primary School	17
Rajol	Primary School	10
	Total	826
	No. of boys studied in villages	74
	Grand Total	900

Table 2 : Size, annual income and per capita income of the families of the sample

Age	Mean No. of family members	Mean No. of adults	Mean No. of children	Mean annual income of the family members in Rs.	Per capita income Rs.
11+	7.3	3.1	4.2	3665	525
12+	7 4	3.3	4.1	3682	520
13+	7.4	3.2	4.3	4420	630
14+	7.8	3.3	4 6	4715	590
15+	8.1	3.6	4.5	4785	595
16+	8.1	3.9	4.2	4683	585
17+	8.7	4.4	4.3	4751	525
18+	8.8	5.1	3.7	5570	615
19+	8.4	4.5	3.8	5497	680

villages as well. They submit these records every year to the respective Panchayat Samiti Offices. Parents are expected to produce birth certificates when they admit their children in schools, especially at the primary level. Furthermore, dates of birth of 25 boys in each yearly age group have been verified either with any available source of records or through recall method. In addition, each boy has been carefully examined for physiological correspondence with the recorded age. The doubtful cases were excluded from the present sample.

The international convention of expressing the age at the last birth day is followed (*cf.* Singh 1970). The mean ages of boys in each age group have been obtained and it is evident from the Table 3, that the mean ages do not, however, markedly differ from the mid-points of the range. For simpler and clear presentation the age groups from 11.00 to 11.99, 12.00 to 12.99, 13.00 to 13.99 years and so on, have been designated as 11+, 12+, 13+, and so on in the present study following Eveleth and Tanner (1976).

Table 3 : Mean ages with Standard Deviation (S.D.) in each year of age

Age-groups (Years)	Abbreviation	Mean age (Years)	S. D.
11-12	11+	11.44	0.26
12-13	12+	12.45	0.23
13-14	13+	13.48	0.27
14-15	14+	14.51	0.25
15-16	15+	15.40	0.26
16-17	16+	16.46	0.25
17-18	17+	17.42	0 26
18-19	18+	18.47	0.26
19-20	19+	19.44	0.24

Health History

Only normal and apparently healthy boys were included in the survey. Boys who have suffered from serious illness in the past three months from the date of examination and those with apparent malformations were excluded from the study.

Puberty Signs and Evaluation of Scores

The developmental stages of primary (genetals) and secondary (pubic, facial and axillary hair) sexual characters of the subjects are rated using the scales described by Tanner (1962). The average stages of pubertal development are studied by calculating frequency distributions and cumulative percentage distributions of the stages in each age group considering different characters separately and collectively.

Nutritional Data, Method and Assessment

The nutritional assessment has been undertaken on a systematic sample of 25 boys from each yearly age group. Every fourth boy in the list of subjects measured, has been selected for this study to minimise any bias. Dietary intake has been orally ascertained by visiting their homes through 24 hour 'recall method'. Furthermore, the raw food taken by the whole family is measured first using household scales or measures. Thereafter, the metric equivalents of the local measures have been established by using a set of standard cups and spoons of varying sizes procured from the National Institute of Nutrition, Hyderabad. Then, the total quantity of each item of the cooked food taken by the subjects has been measured through these standard cups. The number of people who share the meals is also recorded. The quantity of food taken by an individual has been estimated by applying the following formula :

$$\text{Quantity of the raw food of a subject per meal} = \frac{\text{Volume of the subject's intake of food (measured by standard NIN cups)}}{\text{Volume of cooked food taken by the family}} \times \text{Quantity of each raw food taken by the family}$$

The value obtained is then converted into their nutritive values using the tables constructed for India (Gopalan and Balakrishnan 1971). The average nutritive values in terms of calories, proteins, fats, minerals

and vitamins in the food consumed in a day by subjects of each age group are assessed in this way.

Measurements

The following measurements are taken on each boy and all the measurements and definitions of landmarks are taken after Weiner and Lourie (1969) and Singh and Bhasin (1968).

1	Composite measurements	1 Weight 2 Stature
2	Stem measurements	1 Sitting Height Vertex 2 Trunk Height 3 Head and Neck Height
3	Extremity measurements	1 Upper Extremity Length 2 Lower Extremity Length
4	Transverse measurements	1 Biacromial Breadth 2 Bi-iliocristal Breadth 3 Bitrochanteric Breadth 4 Chest Breadth 5 Chest Depth
5	Girth measurements	1 Upper Arm 2 Calf 3 Chest 4 Head
6	Head and Face measurements	1 Head Length 2 Head Breadth 3 Minimum Frontal Breadth 4 Bizygomatic Breadth 5 Bigonial Breadth 6 Morphological Facial Height 7 Morphological Upper Facial Height
7	Skinfold measurements	1 Biceps 2 Triceps 3 Subscapular

However, the lower extremity length is obtained by subtracting sitting height vertex from stature, head and neck height has been measured by subtracting suprasternale from stature and trunk height by subtracting sitting height suprasternale from sitting height surface.

Standardization

The measuring techniques have been standardized in the following manner.

1 Measurements are taken on the left side of the body to control for bilateral differences.

2 When the measurements are taken, the subjects have been put on minimal clothes, *i.e.*, light underwears.

3 A wooden stool is adjusted to keep the subjects feet away from the ground while measuring sitting height. The subject has been made to sit erect with the head in the plane of the visual axis (F H plane).

4 The body weight measurement has been taken on a portable weighing machine.

5 While taking the upper extremity measurement the hand has been hanging freely.

6 The instruments have been cleared every day after use and have been periodically verified for accuracy with the help of a verifactor.

Statistical Considerations

Measures of central tendency (arithmatic mean, standard error of mean and standard deviation) and measure of relative variability (coefficient of variation) are calculated for interpretation of growth data. Frequency distributions of stature and weight are also studied in each age group to examine the pattern of change in the variability of the measurements through the age range from 11+ to 19+ years.

Absolute growth is found by subtracting the mean value of the lower age group from that of the next higher age group. Growth per cent per annum is calculated by the formula :

$$\frac{\text{absolute growth}}{\text{mean value at the lower age group}} \times 100$$

The significance of the increment between successive age groups is tested by using the modified t-test.

The t-test is assumed to be applicable in view of the non-significant differences between variances in successive ages and no apparent deviations of the distributions from normality in almost all measurements.

The trends of age changes are also considered even when the differences are not large enough to show significance at 0.5 level of probability.

For each somatometric trait the distance curve is drawn based on the mean values at different age groups. The velocity curve is based on the absolute growth between different age groups.

Selected centile values are calculated for height and weight and are plotted to obtain centile curves which are useful as standards and also for assessment of the variability of growth within the sample.

The skinfold values obtained have been further transformed into their logarithms to make the distribution of these parameters nearly Gaussian (Tanner, 1962). The transformation used for skinfold is :

Skinfold transform = 100 log (reading in 1/10 mm — 18)

Coefficient of correlations and regression equation, $y = bx + a$, have been calculated for height and weight by age. The regression lines for log weight/stature have also been plotted to have the angle and for type of correlation.

SECTION THREE

RESULTS AND DISCUSSION

Data on Growth

The cross-sectional growth data on Bhil boys in the age-range 11+ to 19+ years for all growth characteristics except skinfold measurements are tabulated in terms of the means for specific yearly age-groups (Table 4), their standard errors (Table 5), standard deviations (Table 6) coefficients of variation (Table 7) average rates of increment per year (Table 8), per cent growth per annum (Table 9) and values of t-test of significance of mean differences between successive years (Table 10). The distance and velocity curves for these growth characteristics are shown in Figures 2 to 24.

Patterns of Progressive Increments

While the patterns of growth of different traits appear to generally agree, there are also some differences in detail between different groups of measurements. The distance curves indicate a progressive increase of each of these measurements from 11+ to 19+ years (Table 5 and Figures 2 to 24). The increments continue to be significant at 5 per cent level between each pair of successive years through the entire age-range of 11+ to 19+ for body weight, head and neck height, chest circumference, biacromial breadth, biiliocristal breadth and bitrochanteric breadth (Table 10). A similar phenomenon of rapid yearly increments throughout the age range is also noticed for chest breadth and chest depth except between 17+ and 18+ years of age ; and also for the girths of upper arm and chest except in the initial years between 11+ and 12+ years. In all these measurements the distance curves are generally characterised by continuation of rapid increment throughout the period. Again, in all these measurements, the rate of increments of growth tend to increase in the last year, between 18+ and 19+ years, preceded by a general decline after the yearly interval between 14+ and 15+ years. This could only be attributed to cross-sectional source of data. In fact, after peak velocity between 14+ and 15+ years there should be a decelerating phase. The growth rate is maximum during 14+ and 15+ years in all these measurements except for biiliocristal breadth.

Growth of Transverse Measurements

Ten of these measurements which generally represent volume and

breadth, except the linear measurement, head and neck height, show a marked adolescent spurt between 14+ and 15+ years of age. The distance curve in each measurement of this group is characterised by a marked concavity upto 15+ years, and for head and neck height upto 16+ years, followed by a straight line of continuous growth in about the same rate. The growth curve of bigonial breadth (Fig. 22) which is also continuous by age, is however, strikingly different in shape being nearly a straight line all through the age. This will be discussed separately along with other cephalo-facial measurements.

In all these measurements, there are two subsequent smaller or minor peaks of velocity, between 16+ and 17+ and 18+ and 19+ years. This is most marked for the biacromial breadth (Fig. 8), and not so remarkable in head and neck height (Fig. 16). In the biiliocristal breadth (Fig. 9) however, the adolescent spurt spreads from 13+ to 15+ years and there is one minor peak from 15+ to 17+ years. In addition to these, there is an earlier peak between 12+ and 13+ years for chest circumference (Fig. 15) between 11+ and 12+ for chest depth (Fig. 12) and head and neck height (Fig. 16). Thus, while there are four velocity peaks for growth of chest breadth (Fig. 11) there are three velocity peaks in all other measurements of this group between 11+ and 19+ years.

Although growth curves are fairly consistent the appearance of multiple-minor peaks other than the adolescent spurt in several different traits which persist in the composite growth might reflect differential and allometric growth of the components of body dimensions. It is, however, not possible to discern from cross-sectional means how far the genetic heterogeneity of the sample might contribute to the minor peaks of velocity or these are true reflections of different periods of accelerated growth in these dimensions. However, an attempt is made to understand this problem by studying the variability and centile curves.

Growth of Linear Measurements

The pattern of yearly increments in stature, sitting height, trunk height, upper extremity length and lower extremity length (Table 4; Figures 2 and 4-7) broadly follows the pattern of growth obtained for the foregoing nine measurements of volume and breadth with some distinctive differences. In these five linear measurements the rate of growth or velocity slows down towards the end of the period. The distance curves appear to reach an asymptote from about 17+ year. The growth curve is sigmoid and from 15+ year onwards it appears to become convex in appearance instead of being straight. It remains concave up to the age of adolescent spurt but the concavity is rather shallow in the case

Table 4 : Means of growth characteristics by age

Growth Characteristics	Age in years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Height vertex (cm)	131.33	134.77	139.84	146.74	155.20	159.52	162.85	163.53	163.97
Sitting height vertex (cm)	68.28	69.94	71.80	75.41	79.51	81.63	82.98	83.51	83.87
Trunk height (cm)	43.49	44.08	44.80	47.41	51.47	53.02	54.49	54.56	54.59
Upper extremity length (cm)	61.35	62.68	65.20	68.62	72.10	74.24	75.79	75.84	76.14
Lower extremity length (cm)	63.05	64.85	68.76	71.33	75.69	78.50	79.87	80.02	80.11
Head and Neck height	24.67	25.35	25.77	26.49	27.67	28.47	28.82	29.17	29.64
Weight (kg)	24.31	25.45	27.83	33.16	38.97	41.82	44.77	46.84	49.23
Biacromial breadth (cm)	27.82	28.38	29.44	30.95	33.14	33.55	34.79	35.31	36.33
Biiliocristal breadth (cm)	19.74	20.36	21.41	22.84	24.25	24.89	25.44	25.73	26.16
Bitrochanteric breadth (cm)	21.38	22.07	23.14	24.70	26.90	27.46	28.02	28.36	28.98
Chest breadth (cm)	10.90	19.46	20.61	21.43	23.10	23.75	24.46	24.74	25.77
Chest depth (cm)	13.92	14.35	14.74	15.53	16.71	17.13	17.60	17.82	18.35
Chest circumference (cm)	61.14	62.49	64.55	67.76	72.84	74.83	76.66	77.81	79.69
Upper arm girth (cm)	16.99	17.11	17.53	18.63	20.17	21.02	21.70	22.02	22.72
Calf girth (cm)	23.71	23.93	24.68	25.97	27.98	28.65	29.49	29.93	30.94
Head length (cm)	16.86	16.95	17.08	17.19	17.40	17.44	17.46	17.65	17.88
Head breadth (cm)	13.06	13.18	13.27	13.34	13.42	13.49	13.58	13.69	13.80
Head circumference (cm)	50.41	50.59	50.76	51.32	52.01	52.44	52.68	53.00	53.16
Minimum frontal breadth (cm)	9.91	9.98	10.01	10.18	10.25	10.33	10.35	10.43	10.44
Bizygomatic breadth (cm)	11.89	12.09	12.13	12.37	12.63	12.78	12.95	12.99	13.10
Bigonial breadth (cm)	9.91	9.17	9.23	9.38	9.58	9.73	9.89	10.11	10.23
Total facial height (cm)	9.89	10.03	10.05	10.17	10.54	10.67	10.85	10.90	10.96
Upper facial height (cm)	6.22	6.39	6.39	6.40	6.54	6.69	6.76	6.82	6.85

Table 5 : Standard Errors of means of growth characteristics by age

Growth Characteristics	11+	12+	13+	14+	15+	16+	17+	18+	19+
Height vertex	0.35	0.31	0.35	0.38	0.38	0.30	0.42	0.53	0.50
Sitting height vertex	0.20	0.20	0.19	0.26	0.19	0.20	0.21	0.23	0.22
Trunk height	0.18	0.16	0.18	0.18	0.26	0.19	0.18	0.16	0.20
Upper extremity length	0.21	0.18	0.22	0.21	0.24	0.19	0.25	0.30	0.31
Lower extremity length	0.18	0.27	0.33	0.24	0.29	0.20	0.33	0.36	0.35
Head and Neck Height	0.07	0.12	0.09	0.11	0.10	0.11	0.11	0.12	0.13
Weight	0.11	0.15	0.25	0.33	0.42	0.40	0.31	0.30	0.33
Biacromial breadth	0.10	0.12	0.14	0.23	0.20	0.20	0.19	0.19	0.18
Biiliocristal breadth	0.14	0.13	0.13	0.12	0.12	0.12	0.11	0.11	0.13
Bitrochanteric breadth	0.13	0.10	0.12	0.12	0.15	0.13	0.12	0.11	0.13
Chest breadth	0.12	0.11	0.09	0.10	0.16	0.15	0.16	0.15	0.17
Chest depth	0.08	0.09	0.09.	0.08	0.10	0.10	0.12	0.08	0.09
Chest circumference	0.24	0.23	0.26	0.32	0.42	0.39	0.29	0.25	0.25
Upper arm girth	0.11	0.10	0.20	0.14	0.17	0.15	0.13	0.12	0.14
Calf girth	0.14	0.12	0.13	0.16	0.19	0.16	0.16	0.15	0.13
Head length	0.05	0.04	0.05	0.06	0.06	0.07	0.05	0.05	0.05
Head breadth	0.04	0.03	0.03	0.04	0.04	0.05	0.04	0.04	0.04
Head circumference	0.12	0.10	0.12	0.13	0.11	0.12	0.10	0.09	0.10
Minimum frontal breadth	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Bizygomatic breadth	0.04	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Bigonial breadth	0.03	0.03	0.03	0.02	0.04	0.04	0.03	0.03	0.03
Total facial height	0.05	0.03	0.04	0.04	0.05	0.04	0.05	0.06	0.05
Upper facial height	0.04	0.03	0.03	0.02	0.04	0.03	0.03	0.04	0.03

Table 6 : Standard deviations of means of growth characteristics by age

Growth characteristics	Age in years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Height vertex	3.45	3.13	3.45	3.79	3.77	2.99	4.22	5.33	5.01
Sitting height vertex	2.02	1.98	1.87	2.57	1.88	2.00	2.09	2.28	2.24
Trunk height	1.78	1.59	1.83	1.83	2.62	1.89	1.78	1.61	1.95
Upper extremity length	2.14	1.80	2.15	2.07	2.43	1.85	2.54	3.01	3.06
Lower extremity length	1.84	2.66	3.29	2.42	2.90	1.97	3.30	3.64	3.50
Head and Neck Height	0.72	1.17	0.85	1.05	0.99	1.14	1.10	1.19	1.27
Weight	1.09	1.52	2.51	3.32	4.24	3.97	3.14	3.03	3.25
Biacromial breadth	1.02	0.80	1.44	2.34	2.00	1.99	1.90	1.87	1.78
Biiliocristal breadth	1.40	1.26	1.26	1.19	1.24	1.15	1.13	1.08	1.30
Bitrochanteric breadth	1.25	1.01	1.20	1.18	1.45	1.26	1.18	1.12	1.29
Chest breadth	1.16	1.05	0.94	0.97	1.60	1.51	1.56	1.50	1.73
Chest depth	0.79	0.92	0.85	0.78	1.04	1.00	1.16	0.79	0.85
Chest circumference	2.37	2.33	2.57	3.24	4.19	3.88	2.94	2.54	2.46
Upper arm girth	1.07	0.97	1.99	1.40	1.66	1.52	1.30	1.20	1.41
Calf girth	1.42	1.22	1.26	1.61	1.88	1.64	1.42	1.50	1.34
Head length	0.52	0.43	0.46	0.56	0.57	0.65	0.54	0.53	0.50
Head breadth	0.48	0.30	0.31	0.37	0.39	0.48	0.37	0.36	0.41
Head circumference	1.22	0.98	1.18	1.28	1.09	1.19	1.04	0.93	1.02
Minimum frontal breadth	0.28	0.26	0.27	0.28	0.26	0.28	0.29	0.29	0.33
Bizygomatic breadth	0.39	0.39	0.30	0.30	0.39	0.39	0.42	0.40	0.43
Bigonial breadth	0.32	0.28	0.28	0.24	0.35	0.33	0.32	0.28	0.28
Total facial height	0.50	0.34	0.37	0.36	0.46	0.40	0.49	0.55	0.54
Upper facial height	0.38	0.29	0.31	0.24	0.41	0.32	0.39	0.36	0.32

Table 7 : Coefficients of Variation (CV) of growth characteristics by age

Growth Characteristics	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Height vertex	2.63	2.32	2.47	2.60	2.43	1.87	2.59	3.26	3.06
Sitting height vertex	2.96	2.83	2.63	3.41	2.36	2.47	2.52	2.73	2.67
Trunk height	4.09	3.61	4.08	3.86	5.09	3.56	3.27	2.95	3.57
Upper extremity length	3.48	2.87	3.30	3.02	3.37	2.49	3.35	3.97	4.02
Lower extremity length	2.92	4.10	4.78	3.39	3.83	2.51	4.13	4.55	4.37
Head and neck height	2.91	4.62	3.30	3.96	3.58	4.00	3.82	4.08	4.28
Weight	4.48	5.97	9.02	10.32	10.88	9.49	7.01	6.47	6.60
Biacromial breadth	3.63	4.37	4.89	7.56	6.04	5.93	5.46	5.30	4.90
Biiliocristal breadth	7.09	6.19	5.89	5.21	5.11	4.62	4.44	4.20	4.97
Bitrochanteric breadth	5.85	4.58	5.19	4.78	5.39	4.59	4.21	3.95	4.45
Chest breadth	6.14	5.40	4.56	4.53	6.93	6.36	6.38	6.06	6.71
Chest depth	5.70	6.41	5.77	5.02	6.22	5.84	6.59	4.43	4.63
Chest circumference	3.88	3.73	3.98	4.78	5.75	5.19	3.84	3.26	3.09
Upper arm girth	6.29	5.67	11.35	7.51	8.23	7.23	5.99	5.45	6.21
Calf girth	5.98	5.10	5.11	6.20	6.72	5.72	5.82	5.01	4.33
Head length	3.08	2.54	2.69	3.26	3.28	3.73	3.09	3.00	2.80
Head breadth	3.67	2.28	2.34	2.77	2.91	3.56	2.72	2.63	2.97
Head circumference	2.42	1.94	2.32	2.49	2.10	2.27	1.97	1.74	1.89
Minimum frontal breadth	2.86	2.61	2.70	2.75	2.54	2.74	2.80	2.78	3.16
Bizygomatic breadth	3.28	3.23	2.47	2.43	3.09	3.05	3.24	3.08	3.28
Bigonial breadth	3.55	3.05	3.03	2.56	3.65	3.39	3.24	2.77	2.74
Total facial height	5.06	3.39	3.68	3.54	4.36	3.75	4.52	5.05	4.93
Upper facial height	6.11	4.54	4.85	3.75	6.27	4.78	5.77	5.28	4.67

Table 8 : Increments (absolute growth) of growth characteristics

Growth Characteristic	Age Groups							
	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Height vertex (cms.)	3.44	5.07	6.90	8.46	4.32	3.33	0.68	0.44
Sitting height vertex (cm.)	1.66	1.86	3.61	4.10	2.12	1.35	0.53	0.36
Trunk height (cms.)	0.59	0.72	2.61	4.06	1.55	1.47	0.07	0.03
Upper extremity length (cm.)	1.33	2.52	3.42	3.48	2.14	1.55	0.05	0.30
Lower extremity length (cm.)	1.80	3.91	2.57	4.36	2.81	1.37	0.15	0.09
Head and Neck Height (cm.)	0.68	0.42	0.72	1.18	0.80	0.35	0.35	0.47
Weight (Kg.)	1.10	2.38	4.33	6.81	2.85	2.95	2.07	2.39
Biacromial breadth (cm.)	0.56	1.06	1.51	2.19	0.41	1.24	0.52	1.02
Biiliocristal breadth (cm.)	0.62	1.05	1.43	1.41	0.64	0.55	0.29	0.43
Bitrochanteric breadth (cm.)	0.69	1.07	1.56	2.20	0.56	0.56	0.31	0.65
Chest breadth (cm.)	0.56	1.15	0.82	1.67	0.65	0.71	0.28	1.03
Chest depth (cm.)	0.43	0.39	0.79	1.18	0.42	0.47	0.22	0.53
Chest circumference (cm.)	1.35	2.06	3.21	5.08	1.99	1.83	1.15	1.88
Upper arm girth (cm.)	0.12	0.42	1.10	1.54	0.85	0.68	0.32	0.70
Calf girth (cm.)	0.22	0.75	1.29	2.01	0.67	0.84	0.44	1.01
Head length (cm.)	0.09	0.13	0.11	0.21	0.04	0.02	0.19	0.23
Head breadth (cm.)	0.12	0.09	0.07	0.08	0.07	0.09	0.11	0.11
Head circumference (cm.)	0.18	0.17	0.56	0.69	0.43	0.24	0.32	0.16
Minimum frontal breadth (cm.)	0.07	0.03	0.17	0.07	0.08	0.02	0.08	0.01
Bizygomatic breadth(cm.)	0.20	0.04	0.24	0.26	0.15	0.17	0.04	0.11
Bigonial breadth (cm.)	0.16	0.06	0.15	0.20	0.15	0.16	0.22	0.12
Total facial height (cm.)	0.14	0.02	0.12	0.37	0.13	0.18	0.05	0.06
Upper facial height (cm.)	0.17	0.00	0.01	0.14	0.15	0.07	0.06	0.03

Table 9 : Growth per annum of growth characteristics between successive age-group

Growth Characteristics	Age Groups							
	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Height vertex	2.62	3.76	4.93	5.77	2.78	2.09	0.42	0.27
Sitting height vertex	2.43	2.65	5.03	5.44	2.66	1.65	0.64	0.43
Trunk height	1.36	1.63	5.83	8.56	3.01	2.77	0.13	0.05
Upper extremity length	2.17	4.02	5.25	5.07	2.97	2.09	0.07	0.40
Lower extremity length	2.85	6.03	3.74	6.11	3.71	1.75	0.19	0.11
Head and neck height	2.76	1.66	2.79	4.45	2.89	1.23	1.21	1.61
Weight	4.52	9.35	15.56	21.18	7.31	7.05	4.62	5.10
Biacromial breadth	2.05	3.74	5.13	7.08	1.24	3.70	1.49	2.89
Biiliocristal breadth	3.14	5.16	6.68	6.17	2.64	2.21	1.14	1.67
Bitrochanteric breadth	3.23	4.85	6.74	8.91	2.08	2.04	1.11	2.29
Chest breadth	2.96	5.91	3.98	7.79	2.81	2.99	1.14	4.16
Chest depth	3.09	2.72	5.36	7.60	2.51	2.74	1.25	2.97
Chest circumference	2.21	3.30	4.97	7.50	2.73	2.45	1.50	2.42
Upper arm girth	0.71	2.45	6.27	8.27	4.21	3.24	1.47	3.18
Calf girth	0.93	3.13	5.23	7.74	2.39	2.93	1.49	3.37
Head length	0.53	0.77	0.64	1.22	0.23	0.11	1.09	1.30
Head breadth	0.92	0.68	0.53	0.60	0.52	0.67	0.81	0.80
Head circumference	0.36	0.34	1.10	1.34	0.83	0.46	0.61	0.30
Minimum frontal breadth	0.71	0.30	1.70	0.69	0.78	0.19	0.77	0.09
Bizygomatic breadth	1.68	0.33	1.98	2.10	1.19	1.33	0.31	0.85
Bigonial breadth	1.78	0.65	1.63	2.13	1.57	1.64	2.22	1.19
Total facial height	1.42	0.20	1.19	3.64	1.23	1.69	0.46	0.55
Upper facial height	2.73	0.00	0.16	2.19	2.29	1.05	0.89	0.44

Table 10 : *Values of 't' test of significance for growth characteristics*

Growth Characteristics	Age Groups							
	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Height vertex	9.83	16.35	19.71	22.26	11.37	11.10	1.62	0.83
Sitting height vertex	8.30	9.30	19.00	15.77	11.16	6.75	3.48	1.57
Trunk height	3.28	4.50	14.50	22.56	5.96	7.74	0.39	0.19
Upper extremity length	6.30	14.00	15.55	16.57	8.92	8.16	0.20	1.00
Lower extremity length	10.00	14.48	7.79	18.17	9.69	6.85	0.45	0.25
Head and Neck height	9.71	3.50	8.00	10.73	8.00	3.18	3.18	3.92
Weight	10.00	15.87	17.32	20.64	6.79	7.38	6.69	7.97
Biacromial breadth	5.60	13.25	10.79	9.52	2.05	6.20	2.74	5.37
Biiliocristal breadth	4.43	8.08	11.00	11.75	5.33	4.58	2.64	3.91
Bitrochanteric breadth	5.31	10.70	13.00	18.33	3.73	4.31	2.58	5.91
Chest breadth	4.67	10.45	9.11	16.70	4.06	4.73	1.75	6.87
Chest depth	5.38	4.33	8.78	14.75	4.20	4.70	1.83	6.63
Chest circumference	5.63	8.96	12.35	15.88	4.74	4.69	3.97	7.52
Upper arm girth	1.09	4.20	5.50	11.00	5.00	4.53	2.46	5.83
Calf girth	1.57	6.25	9.92	12.56	3.53	5.25	3.14	6.73
Head length	1.80	3.25	2.20	3.50	0.67	0.29	3.80	4.60
Head breadth	3.00	3.00	2.33	2.00	1.75	1.86	2.75	2.75
Head circumference	1.50	1.70	4.67	5.31	3.91	2.00	3.20	1.78
Minimum frontal breadth	2.33	1.00	5.67	2.33	2.67	0.67	2.67	0.33
Bizygomatic breadth	5.00	1.00	8.00	8.67	3.75	4.25	1.00	2.75
Bigonial breadth	5.33	2.00	5.00	10.00	3.75	5.33	7.33	4.00
Total facial height	2.80	0.67	3.00	9.25	2.60	4.50	1.00	1.00
Upper facial height	4.25	0.00	0.33	7.00	3.75	2.33	2.00	0.75

of limb lengths than in trunk length or sitting height. The rate of growth per annum is significant up to 17+ years but not significant after this age group in four of these traits and after 18+ year of age for sitting height vertex in the present data. The growth rates beyond this age are too small to be estimated from cross-sectional data for the sample size of 100 individuals per yearly age group. But it is quite likely that a slow rate of linear growth continues for some more time after 17+ or 18+ years among the Bhil boys as in the other populations (Tanner, 1977).

The growth curves of four of these measurements except the lower extremity length are generally characterised by gradual acceleration up to the age of adolescent spurt, 14+ and 15+ years and a deceleration after that age. In the lower extremity length (Fig. 7), however, there is also a large peak velocity between 12+ and 13+ years and in addition to the sharp adolescent spurt between 14+ and 15+ years of age as observed in most of the other traits. The growth velocity in the lower extremity length appears to resemble that of chest breadth in this respect. The adolescent spurt is less sharp for upper extremity length (Fig. 6) and for sitting height vertex (Fig. 4) it spreads from 13+ and 15+ years. The difference in the growth curves between trunk height and sitting height may be attributed to the contribution of the earlier increase in velocity of growth of the neck length to sitting height vertex. This refers to the segmental growth of neck length in respect of sitting height vertex and height vertex.

A small velocity peak is observed between 16+ and 17+ years besides the adolescent spurt in most of the linear measurements with the exception of lower extremity length. The growth of the lower extremity length (Fig. 7) also tends to show a very small peak of velocity in this age which may have an allometric relationship with the prominent peak in this age shown by the biacromial breadth (Fig. 8). It may be stated, therefore, that both the pectoral and pelvic girdles have second rise of growth rate after the age of adolescent spurt between 14+ and 15+ years. It is noteworthy that the adolescent spurt is less sharp and spreads from 13+ to 15+ years in the sitting height vertex (Fig. 4) and from 11+ to 14+ years in the upper extremity length (Fig. 6). It is difficult to decipher from these data the cause of the smoothness of the adolescent spurt in the growth curve and the appearance of smaller peaks of the velocity in this complex of upper extremity length and sitting height vertex.

Segmental Growth

There is apparently a greater similarity of the growth curve of the

sitting height vertex with that of trunk height than with that of the head and neck height. The appearence of an earlier velocity peak of the head and neck height (Fig. 16) between 11+ and 12+ years before the age of adolescent spurt is not so marked in the growth curve of sitting height vertex (Fig. 4) although head and neack height forms a major segment cf sitting height.

Again, irregularities in the velocity curves with multiple peaks of sitting height and lower extremity length (Fig. 4 & 7) become very much smoothened in the growth curve of height vertex. From this it appears that the two components of sitting height vertex and lower extremity length constitute equally to the growth of height. The adolescent spurt appears to be sharper in the case of height vertex than in either of the two components. The large velocity of growth occuring earlier between 13+ and 14+ years in sitting height vertex is compensated by a decline in the velocity of growth during the age in lower extremity length. The earlier sharp peak of velocity between 12+ and 13+ years in lower extremity length is again compensated by very low rate of growth in sitting height vertex during that year of age. It displays an allometric relationship of growth between the two major segments of height. The sharp adolescent peak between 14+ and 15+ years for height vertex is due to the simultaneous occurence of high velocity of growth in each of the two components. A small increase of growth velocity between 16+ and 17+ years is limited to sitting height vertex only and this peak of growth velocity is much less prominent in the velocity curve of height vertex. Thus the segmental growth shows significantly the fact that the increase in stature in the initial years of adolescence among the Bhil boys is due more to the growth of lower extremity length and in later years it is due more to the growth of the trunk.

Cephalo-facial Measurements

The annual growth has also been looked for in respect of eight cephalo-facial measurements. They are grouped together due to relatively closer similarity between their mean curves. The distance and velocity curves of head length (Fig. 17), head breadth (Fig. 18), head circumference (Fig. 19), minimum frontal breadth (Fig. 20), bizygomatic breadth (Fig. 21), bigonial breadth (Fig. 22), total facial height (Fig. 23) and upper facial height (Fig. 24 ; Tables 4, 8 & 9) seem to conform to earlier observations regarding striking differences in the growth pattern between cephalo-facial and non-cephalic measurements during adolescence.

A distinct but small adolescent spurt can be apparently located

between 14+ and 15+ years only in respect of head circumference and total facial height. The distance curves of these measurements only appear to be of the usual sigmoid shape but with slight disturbances and smaller deviation from linearity than the growth curves for the volume or breadth and vertical measurements. The minimum frontal breadth also exhibits an adolescent spurt between 13+ and 14+ years. The peak velocities appearing between 14+ and 15+ years for head length, bizygomatic breadth, bigonial breadth and upper facial height are counter-balanced by approximately similar peaks of velocity between 17+ and 19+, 17+ and 18+, 15+ and 16+, 13+ and 14+ years respectively. The velocities of growth for bigonial breadth and bizygomatic breadth have again a considerably large peaks between 11+ and 12+ years and for head length between 12+ and 13+ years. The adolescent spurt of head circumference is again not so sharp because there is nearly similar increase of velocity in the earlier age groups between 13+ and 14+ years. All these measurements are characterized by multiple peaks of velocity. The sharpest indication of adolescent spurt within these limited variation of growth in this group of measurements is displayed by total facial height and minimum frontal breadth (Fig. 20 and 23) although the age of spurt differs between them.

The significant annual increments at 5% level of probability in these cephalo-facial measurements are only observed for a part and not the whole of the period of adolescence. The ages of these periods of significant growth differ between traits (Table 10).

Some allometric relationships of growth can be observed between the measurements of head and face also. There is some underlying correspondence and complementary nature of the velocities of growth of minimum frontal breadth, bizygomatic breadth and bigonial breadth to some extent. An earlier peak velocity from 11+ to 12+ years occurs in the growth of all breadth measurements of the head and face, in the head and neck height together with the growth of lower extremity length.

Differential growth

A graphical comparison of the different rates of growth of different body dimensions through the age range 11+ to 19+ years brings out the uniformity and diversity of growth patterns in different bodily traits (Fig. 27). In this diagram, the per cent growth of each dimension in different age groups from the mean measurements attained at 11+ years are plotted (Table 11). Each vertical line joins the points indicating per cent growth of different characters attained in a perticular age namely, 12+, 13+, 14+ ana so on. The measurements are arranged from above

downwards in decreasing order of their per cent growth at 19+ year age group. Thus, the maximal amount of growth is obviously attained by weight (102%) the disproportionately high values of which are not represented in the diagram. The growth of breadth and circumferences follow next in order. The growth of limb lengths, trunk length and height vertex occupy the intermediate position, and growth attained by head and facial measurements appear to be the least of all.

However, the differential pattern of growth varies in different age groups. For example, there is much greater amount of growth in hip breadth, chest breadth and lower extremity length in the initial period of adolescence upto around 14+ years. The amount of growth of some measurements on face and head and neck height are also comparable to these bodily dimensions in the initial years of adolescence.

It is brought out by arranging the traits in the rank order of their magnitude of growth in each age that ;

1. Weight displays maximum percentage of growth throughout the age range 11+ to 19+ years.

2. The lower extremity length shows maximum growth only in the initial years of adolescence.

3. The girth measurements display small percentage of growth in the initial years but attain a much higher rank in growth rate among the traits towards the late adolescence.

4. The linear measurements such as lower extremity length, trunk height, height vertex, upper extremity length and sitting height gain the least percentage growth after 17+ year.

5. The bigonial breadth shows the maximum percentage of growth among all head and facial measurements.

6. A striking feature of this graph is the emergence of three broad groups of traits which show similar rates of growth. Volume and breadth measurements attain higher per cent growth followed by vertical and head measurements.

7. While in most of the traits maximal increase is observed between 14+ and 15+ years, in a few measurements such as upper facial height, biiliocristal breadth and upper extremity length, the maximal amount of growth is observed in more than one yearly interval.

Table 11 : *Value of percent growth of each growth trait in different age-groups from the mean values attained at* 11+ *years*

Growth Characteristics	Age Groups							
	11-12	11-13	11-14	11-15	11-16	11-17	11-18	11-19
Weight	4.52	14.29	32.07	60.04	71.75	83.86	92.36	102.18
Chest breadth	2.96	9.05	13.39	22.22	25.66	29.42	30.90	36.35
Bitrochantenic breadth	3.23	8.23	15.53	25.82	28.44	31.06	32.51	35.55
Upper arm girth	0.71	3.18	9.65	18.72	25.72	27.72	29.61	33.73
Biiliocristal breadth	3.14	5.46	15.70	22.55	26.09	28.88	30.34	32.52
Chest depth	3.09	3.89	11.57	20.04	23.06	26.44	28.02	31.82
Biacromial breadth	2.05	5.82	11.25	19.12	20.60	25.05	26.92	30.59
Calf girth	0.93	4.09	9.53	18.01	20.84	24.38	26.23	30.49
Chest circumference	2.21	5.58	10.83	19.14	22.39	25.38	27.27	30.34
Lower extremity length	2.85	9.06	13.13	20.05	24.50	26.65	26.92	27.06
Trunk height	1.36	3.01	9.01	18.35	21.91	25.29	25.45	25.52
Height vertex	2.62	6.48	11.73	18.18	21.47	24.00	24.52	24.85
Upper extremity length	2.17	6.28	11.85	17.52	21.01	23.54	23.62	24.11
Sitting height vertex	2.43	5.16	10.44	16.45	19.55	21.53	22.31	22.83
Head and neck height	2.76	4.46	7.38	12 16	15.40	16.82	18.24	20.15
Bigonial breadth	1.78	2.44	4.11	6.33	7.99	9.77	12.21	13.54
Total facial height	1.42	1.62	2.83	6.57	7.89	9.71	10.21	10.82
Bizygomatic breadth	1.68	2.02	4.04	6.22	7.49	8.92	9.25	10.18
Upper facial height	2.73	2.73	2.89	5.14	7.56	8.68	9.65	10.13
Head length	0.53	1.30	1.96	3.20	3.44	3.56	4.69	6.05
Head breadth	0.92	1.61	2.14	2.76	3.29	3.98	4.75	5.67
Head circumference	0.36	0.71	1.81	3.17	4.03	4.50	5.14	5.46
Minimum frontal breadth	0.71	1.01	2.72	3.43	4.24	4.44	5.25	5.35

Table 12 : Percent adult growth values attained by each growth trait considering the 19+ year as the base year of 100

Growth Characteristics	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Height vertex	80.09	82.19	85.28	89.49	94.65	97.29	99.32	99.73	100.00
Sitting height vertex	81.41	83.39	85.61	89.91	94.80	97.33	98.94	99.57	100.00
Trunk height	79.67	80.75	82.07	86.85	94.28	97.12	99.82	99.95	100.00
Upper extremity length	80.58	82.32	85.63	90.12	94.69	97.50	99.54	99.61	100.00
Lower extremity length	78.70	81.95	85.83	89.04	94.48	97.99	99.70	99.89	100.00
Head and neck height	83.23	85.53	86.94	89.37	93.35	96.05	97.23	98.41	100.00
Weight	49.38	51.70	56.53	65.33	79.16	84.95	90.94	95.15	100.00
Biacromial breadth	76.58	78.12	81.03	85.19	91.22	92.35	95.76	97.19	100.00
Bitrochanteric breadth	73.78	76.16	79.85	85.23	92.82	94.76	96.69	97.86	100.00
Biiliocristal breadth	75.46	77.83	81.84	87.37	92.70	95.15	97.25	98.36	100.00
Chest breadth	73.34	75.51	79.98	83.16	89.64	92.16	94.92	96.00	100.00
Chest depth	75.86	78.20	80.33	84.63	91.06	93.35	95.91	97.11	100.00
Chest circumference	76.71	78.42	81.00	85.03	91.40	93.90	96.20	97.64	100.00
Upper arm girth	74.78	75.31	77.16	82.00	88.78	92.52	95.51	96.92	100.00
Calf girth	76.63	77.34	79.77	83.94	90.43	92.60	95.31	96.74	100.00
Head length	94.30	94.80	95.53	96.14	97.32	97.54	97.65	98.71	100.00
Head breadth	94.64	95.51	96.16	96.67	97.25	97.75	98.41	99.20	100.00
Head circumference	94.83	95.17	95.49	96.54	97.84	98.65	99.10	99.70	100.00
Minimum frontal breadth	94.92	95.59	95.88	97.51	98.18	98.95	99.04	99.90	100.00
Bizyomatic breadth	90.76	92.26	92.60	94.43	96.41	97.56	98.85	99.16	100.00
Bigonial breadth	88.07	89.64	90.22	91.69	93.65	95.11	96.68	98.83	100.00
Total facial height	90.24	91.51	91.70	92.79	96.17	97.35	99.00	99.45	100.00
Upper facial height	90.80	93.28	93.28	93.43	95.47	97.66	98.69	99.56	100.00
Male genitals	22.40	37.20	51.40	64.80	74.60	79 20	87.00	99.80	100.00
Pubic hair	20.20	25.80	34.00	49.20	64.00	70.40	80.20	91.40	100.00
Facial hair	33.33	33.33	35.00	43.67	61.67	65.00	71.00	95.33	100.00
Axillary hair	33.33	33.33	33.33	38.33	48.70	56.00	67.70	84.00	100.00

Gradients of growth

The maturity gradients of different measurements are brought out by plotting the percentage of adult value (that is the mean value at 19+ year) obtained at each age (Table 12 ; Fig. 28) following the earlier attempt by Scammon (1927).

The data suggest cephalo-caudal gradient of growth during adolescence in Bhil boys. In all ages of adolescence the head is nearer the adulit size than other body dimensions and is followed by facial, linear, transverse measurements of girths and breadths and body weight in order. When the average grades of the four aspects of the sexual maturation, studied in each year are expressed as percentages of the maximal grade attained in the 19+ year, it becomes apparent that reproductive development in males is behind the growth and development of different other body dimensions. This agrees with the Scammon's (1927) earlier suggestion.

Furthermore, the data also suggest that within each of the aforesaid six groups of characters, there are also maturity gradients of growth in timing. For example, within head and face measurements, the most advanced growth is observed for morphological facial height. There may also be an antero-posterior gradient in head. The growth of lower parts of the face such as bigonial breadth lags behind that of the bizygomatic breadth. Within the linear measurements, again, there may be an apparent trend of cephalo-caudal gradient. The head and neck height and sitting height show relatively advanced maturity levels in each age than the measurements of lower extremity length, which have relatively delayed maturity. The development of genitalia representing the primary sexual character is also in advance compared to the secondary sexual characters and growth of pubic hair is more advanced than facial and axillary hair except in the initial year of adolescence.

Variability

Variations in body dimensions and proportions at any stage of growth and development would occur as a result of differential growth rates and sex differences. An apparent correlation between variability and rates of growth has been studied by Boas (1932), Schultz (1926) amongst others. It might imply that variability fluctuates at different ages in accordance with the rate of growth.

(a) *Standard deviations* : In the present study the variability of most of the measurements as estimated by standard deviations generally in-

creases in the initial years of adolescence and thereafter declines. The maximal variation in respect of height vertex and lower extremity length appear to occur towards the end of the adolescence period. This is mainly because of the growing role of hereditary factors.

(b) *Coefficients of variation* : Variability in body dimensions as judged from coefficients of variation and the range of maximum and minimum, reveal higher values during periods of faster growth and lower values during periods of slower growth. Also, for instance, height vertex has shown less variability as compared to its segments namely head and neck height, trunk height and lower extremity length at any age level.

Frequency Distributions of Stature and Weight

The process of growth in these cross-sectional data are also studied through a comparison of the frequency distributions for height and weight measurements in successive age groups (Figures. 25 and 26). Generally the modal values appear to move up in slow steps through successive years except a major leap during the adolescent spurt, and negligible shift of the mode towards the end of the adolescence period. This is clearly observed in graphs of distribution as for height vertex and weight in which a second higher peak appears to develop in the following years. The minor peaks already observed in the earlier year becomes magnified in the following years. An examination of these curves does not provide definite evidence against the possibility of a later adolescent spurt in some individuals, because at 15+ year very few subjects show the stature between 160—165 cms but in a considerably large proportion of boys of 16+ and 17+ years of age appear to attain such heights. However, if the difference of modes are considered as a measure of increment, the growth rate between 13+ and 14+ years is greater than that of successive years from 14+ to 17+ years. The comparison of modal values between successive age groups thus brings out a variability in the age of adolescent spurt even in the cross-sectional data.

The later adolescent spurt shown by the mean values as in height vertex is obviously due to a large proportion (about 31%) of boys in 14+ year who lag behind the modal value. The distribution of higher age groups fails to show any clear modes which suggest the slowing down of growth rate.

Centile Curves and Growth Standards

The centile curves of growth are also drawn for height and weight (Table 13 ; Figures. 29 and 30) as these estimates from cross-sectional studies are usually helpful in providing population standards (Eveleth

Table 13 : *Selected percentile values for height and weight by age*

Growth Character/Percentile	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Stature (*Cms.*)									
5th	124.50	128.67	133.07	140.31	149.81	152.62	153.07	154.50	154.50
10th	125.33	129.92	134.81	141.11	150.32	155.75	156.64	155.50	155.69
25th	128.50	131.48	136.34	141.62	151.85	156.23	159.24	158.50	159.26
50th	130.97	134.08	138.89	146.11	154.40	158.79	162.66	162.95	163.50
75th	132.81	136.94	142.29	148.23	157.58	161.75	166.17	167.36	167.42
90th	133.91	138.69	144.50	149.50	159.50	163.63	168.44	170.75	170.33
95th	134.28	139.27	147.00	152.00	162.28	164.25	169.20	172.83	172.42
Weight (*Kg.*)									
5th	21.00	21.98	24.57	27.50	32.30	34.70	40.07	42.59	43.17
10th	21.77	22.58	24.90	27.97	33.86	36.50	40.79	43.01	44.83
25th	22.77	24.36	25.90	29.38	35.66	39.50	42.70	44.30	47.00
50th	24.43	25.56	27.58	31.72	38.95	41.53	44.37	46.27	49.36
75th	26.03	26.66	29.50	34.22	41.60	44.45	46.70	48.70	51.14
90th	26.99	27.32	31.00	36.02	44.75	47.68	49.50	51.50	53.64
95th	27.31	28.00	32.25	37.50	47.30	49.36	51.17	53.16	55.10

and Tanner, 1976). Particularly the inner centiles such as 25th, 50th and 75th are subject to substantially less sampling error (Tanner, 1962 Goldstein, 1972 ; Heald *et al*, 1969) than the outer ones such as the 3rd and 97th. The curves of 50th percentile values, however, do not markedly differ from the growth curves based on mean values. Secondly, the percentile curves in these data are relatively more parallel to one another than the other Indian data (ICMR, 1972).

SECTION FOUR

DATA COMPARISON

Comparison with selected Indian Populations

Since majority of growth studies in India are restricted to few bodily dimensions such as height and weight the comparison of the present data also has been limited to these composite measurements. Thus the mean height and mean body weight of Bhil boys have been compared with those of specific endogamous populations (Table 14 and 15) like Maharashtra Brahmins of Gwalior (Sharma, 1970), the Punjabi Khatris of Delhi (Singh 1970), the Mundas/Oraons of Chota Nagpur (Sharma *et al.*, 1975), the Bods of Ladakh (Malik and Singh, 1978) and those of 'All India' (ICMR, 1972) and South India (NRL, 1959). An examination of table 14 and 15 leads us to the following observations.

(1) The adolescent Bhil boys are shorter and lighter than the boys of the same ages as observed among the Maharashtra Brahmin, Punjabi Khatris and urban South Indian boys.

(2) The Bod boys of Himalayan region are shorter than Bhil boys atleast from 11+ years to 17+ years. However, Bod boys are heavier than the Bhil boys all through the adolescent years, *i.e.*, from 11+ years to 19+ years.

(3) Bhil boys are shorter than Munda/Oraons from the initial years of adolescence (11+ years) uptil 15+ years of age and thereafter Bhil boys remain taller than Munda/Oraons for the rest of period of adolescence. Considering the weight Munda/Oraon boys remain heavier than Bhil boys althrough the period of adolescence.

(4) Bhil boys are taller and heavier than South Indian rural boys althrough the age.

(5) Bhil boys are shorter and lighter than the children who represent All India only in the initial years of adolescence but in the later part of adolescence, *i.e.*, from 15+ to 19+ years the Bhil boys display more height and weight.

(6) Except Maharashtrian Brahmins and Punjabi Khatris, the Bhil boys show closer resemblance with the rest of the population considered here atleast in one or two years during the period of adolescence.

Table 14 : *Comparison of heights* (*Cms.*) *of Bhil boys with the selected Indian populations*

Age Group	Bhils	Maharastra Brahmins	Punjabi Khatris	Munda/ Oraons Chotanagpur	Bods of Ladakh	All-India	South India		
							Urban	Semi-Urban	Rural
11+	131.3	134.0	138.3	136.8	128.0	133.4	135.5	129.4	129.9
12+	134.8	136.4	144.1	140.8	133.7	138.3	140.7	134.5	135.0
13+	139.8	140.8	150.6	141.5	135.9	144.6	145.3	140.4	139.0
14+	146.7	151.4	155.4	147.4	143.4	150.1	152.4	147.6	143.9
15+	155.2	159.7	159.3	156.0	150.3	155.5	157.1	150.6	149.2
16+	159.5	161.7	165.6	156.7	157.9	159.5	161.1	157.6	155.4
17+	162.8	163.8	167.3	160.2	161.1	161.4	161.2	161.8	158.3
18+	163.5	166.0	167.9	161.7	163.7	163.1	161.8	163.5	161.2
19+	164.0	167.0	—	164.0	167.8	163.5	165.7	163.2	161.7

Table 15 : *Comparison of weights* (*Kg.*) *of Bhil boys with the selected Indian populations*

Age Group	Bhils	Maharashtra Brahmins	Punjabi Khatris	Munda/ Oraons Chota-Nagpur	Bods of Ladakh	All-India	South India		
							Urban	Semi-urban	Rural
11+	24.3	26.5	28.7	26.9	24.5	25.9	26.7	23.3	23.5
12+	25.5	28.5	33.4	31.4	26.9	28.5	30.0	25.8	25.8
13+	27.8	34.2	36.6	30.5	27.8	32.1	32.1	28.7	28.4
14+	32.2	38.4	39.5	34.5	32.2	35.7	37.8	33.8	30.9
15+	39.0	43.1	43.6	43.2	37.7	39.6	41.5	35.3	34.5
16+	41.8	46.0	48.8	44.3	43.9	43.2	43.9	40.4	38.7
17+	44.8	48.2	51.5	49.3	46.8	45.7	44.3	43.0	42.5
18+	46.8	49.6	53.0	50.2	51.6	47.4	46.3	45.0	43.9
19+	49.2	49.8	—	51.58	57.5	48.1	47.7	46.6	45.8

These resemblances and differences are greater in the higher age groups from 15+ to 19+ years than the lower age groups. Thus, all the stated differences are obviously systematic differences and may be attributed to the ethno-genetic factors from the biological point of view.

Weight for Height

A graphical analysis of mean weight for mean height of boys in the 16+ year age group demonstrates that Bhil boys are shorter and lighter than most of the Indian boys. They are, however, taller and heavier than adolescent boys from Kerala, Tamil Nadu, Nagpur, Poona, South India semi-urban and rural and Chittoor urban and rural. Furthermore, Bhil boys are taller and lighter than the Bod boys (Fig. 31).

Comparison with non-Indian Data

Data on height, weight, sitting height, biacromial breadth, biiliac breadth, chest circumference, upper arm girth, calf girth, triceps and subscapular skinfolds are available from all continents. A comparison of growth data of adolescent Bhil boys with non-Indian data compiled by Eveleth and Tanner (1976) leads to the following observations.

The growth patterns of Bhil boys during adolescence as reflected in the rates of growth, the time of adolescent spurt, as also the mean values of different traits attained by them in younger ages appear to be generally more similar to the adolescent boys of corresponding ages belonging to the tribal and backward populations of each region of world than those belonging to the advanced and better off sections of these areas. They also show marked ethnic difference in this respect from caucosoid populations in general. The size of different dimensions in the age groups among adolescent Bhil boys are thus broadly comparable to the Gypsis of Czechoslovakia, the Maya Indians of Guatemala, the Zapotec Indians of Mexico, the rural boys of Philippines and Malays of Singapore. In Africa, the adolescent boys from the Hutus of Rwanda and the Bush Negroes of Surinam, Kisi and Nyakyusa of Tanzania resemble the adolescent Bhil boys in this respect. The tribal boys of Australia, Bundi, Kaiapit, Karkar, Lumi and Manus of New Guinea, also show similar patterns of growth as displayed by Bhil boys.

The mean weight for height at 16+ year age is smaller in the Bhil boys in comparison to the data available all through the world except Lumi boys of New Zealand, Quechua boys of Peru and Hutu boys of Rwanda.

The comparative study of growth of Bhil boys with available data

from India and other parts of the world indicate that Bhil boys have a slow growth rate in the initial period of adolescence followed by a fast growth during the spurt which is rather delayed. As a result, the average dimensions attained by Bhil boys in the early adolescence are rather low in comparison to other populations except a very few Indian and non-Indian populations such as those of Kerala, poor socio-economic strata from India, rural children from different parts of India and isolated tribes such as Bundi of New Guinea, the Hutu of Africa, the Maya Indians of America. However, in the post spurtal ages the Bhil boys are rather heavier than the boys of the rural areas or from low socio-economic groups and those of certain geographical areas such as Southern and Western India.

SECTION FIVE

PHYSICAL CHANGES

The physical growth in boys during adolescence is obviously related to some qualitative changes in the body through age in course of transition from childhood to adulthood. Sexual development, the changes in the thickness of subcutaneous fat and changes in the shape of the body due to altered ratio of different body dimensions, are some of the major features of the physical changes during adolescence, and the data from these three aspects are analysed for the Bhil boys of each year of age from 11+ to 19+ years.

Shape changes due to relative body dimensions

In the foregoing section changes in the body dimensions by age were observed by means of distance and velocity curves. It was observed that the dimensions generally increased with age. A more minute observation of the results would, however, reveal that various body traits differ considerably as to their pattern and rate of increase over the age range considered. For a quantitative and graphical description of the growth change taking place in the component parts in relation to the total body, morphological ratios or indices serve as good criteria. Shape, as a matter of fact, is defined in terms of relationship between a pair of measurements of body segments following Huxley's (1932) idea of bivariate allometry. The following account attempts to discuss the growth of one trait of the body in relation to other at various ages, in terms of indices of body proportions.

1. *Weight : height index* (*Fig.* 32)

There is a continuous increase in the mean values of the weight : height index from 11+ to 19+ years. This continuous increase of the index indicates that although body weight and height are increasing at each age, the rate of growth in body weight is relatively higher than that of stature. This is obvious because the increase in body weight is due not only to the growth of the body in linear dimension but also due to the growth of the body in other dimensions. Boby weight is the total of weights of all the parts of the body in whatever directions they are growing at a particular age. The maximum increase of the index is observed between 14+ and 15+ years.

2. *Rohrer's Index* (*Fig.*33)

Owing to the fact that weight is a ponderal measurement and stature a linear one, the relationship between the two expressed in terms of a simple weight height ratio, does not give a clear picture of the body conformation. This defect has been overcome by expressing weight as percentage of cube of stature. This index, termed Rohrer's body build index, thus, attempts to expresss more clearly the relationship between weight and stature rather than a simple weight : height ratio.

The mean values of this index exhibit a continuous fall from 11+ years to 14+ years and a continuous raise from 16+ to 19+ years. The fall in the values may be accounted for the rapid growth of lower limbs (which constitute almost 50% of stature) during the growth period prior to puberty. The raise in values in the later years of adolescence may be accounted for growing importance of weight.

3. *Ponderal index* (*Fig.* 34)

Montessori's ponderal index is a simple measure of shape or build of body. It is expressed as stature devided by the cube-root of weight, and is often employed for measuring and comparing weight relative to stature. It indicates linearity of build (Hubber, 1969). In other words, 'the purpose of this index is to equate weight and stature in proportion to the weight change normal for a given increment of stature' (Osborne & De George, 1959). This index contrary to the Rohrer's index, is an attempt to achieve similar ends by computing cube-root of the weight. An increasing trend is seen in the mean values from 11+ to 14+ years and similar decreasing trend from 16+ to 19+ years, thereby strengthening the inference obtained through Rohrer's index.

Regression of weight on height

The relationship of weight and height in different ages of adolescence is also examined by obtaining the product moment coefficient of correlation and also the coefficient of regression of weight on height in different ages (Table 16). Both these coefficients display the largest value in the boys of 14+ years. There is a slight decline of the correlation at 12+ year and again it is most reduced at 16+ year and at 19+ year of age. The beginning of the proportionately greater growth in weight at these ages is likely to reduce the predictability of weight from height. The values of regressions gradually decline with age upto the 14+ year.

Regression lines : In Fig. 35 the points on the observed regression lines are plotted, those for the regression of x on y being marked by

Table 16 : Results of Products moment coefficient of correlation (r) and coefficient of regression analysis of weight (b)

Age Years	Correlation coefficient	S. E. of 'r'	b
11+	0.555	0.069	0.336
12+	0.419	0.082	0.203
13+	0.543	0.070	0.395
14+	0.618	0.061	0.734
15+	0.449	0.079	0.505
16+	0.366	0.086	0.487
17+	0.489	0.076	0.363
18+	0.607	0.063	0.347
19+	0.393	0.084	0.255
11-19	0.905	0.006	0.674

crosses and those for the regression of y on x by circles. It is inferred from this graph that the result of acute angle between the lines indicates a fairly high correlation between 'x' and 'y'. It is found, in fact, that r=0.905 and S.E. of 'r'=0.006.

4. *Sitting height : stature index* (*Fig.* 36)

This index holds good for observing proportional growth between stature and sitting height. From table 17 and figure 36 there appear to be broadly two different trends. The index decreases continuously from 11+ years to 16+ years except in 14+ years and thereafter it increases till the end of adolescence, *i.e.*, 19+ years. This clearly speaks that the decrease in index is due more to the growth in stature and increase in the index values from 16+ onwards is due to more growing importance of trunk portion than that of lower limbs.

5. *Chest circumference : Stature index* (*Fig.* 37)

This index is important to know about the growth of chest in relation to stature. As seen in the study of growth, the breadth measurements show a general similarity in the pattern of growth with that of weight. The growth of chest dimensions during adolescence obviously leads to a marked change in the shape of the body. The variation of this index through age shows more resemblance with Rohrer's index.

Table 17 : Mean values of indices in each year of age

Index	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Weight height	18.52	18.88	19.89	21.92	25.11	26.23	27.49	28.64	30.02
Rohrer's	1.07	1.04	1.02	1.02	1.04	1.03	1.04	1.07	1.12
Ponderal	4.54	4.58	4.61	4.62	4.60	4.59	4.59	4.53	4.47
Sitting height : Stature	52.02	51.94	51.35	51.39	51.25	15.16	50.96	51.08	51.18
Chest girth : stature	46.57	46.37	46.17	46.18	46.94	46.97	47.08	47.61	48.63
Chest depth : Chest breadth	73.71	73.31	71.54	72.47	72.44	72.18	71.82	72.14	71.34
Intermembral	91.93	89.92	90.65	92.18	90.41	90.33	90.53	90.56	90.58
Acromion : iliac	70.99	71.74	72.56	73.87	73.26	74.16	73.21	72.98	72.09
Androgeneity	4.23	4.19	4.15	4.04	4.10	4.10	4.10	4.10	4.17
Calf girth : Chest girth	38.80	38.30	38.24	38.36	38.47	38.31	38.48	38.49	38.82
Upper arm girth : Chest girth	27.79	27.38	27.16	27.47	27.67	28.08	28.30	28.30	28.50
Upper arm girth : Calf girth	71.73	71.53	71.01	71.79	72.07	73.42	73.63	73.67	73.46
Cephalic	77.48	77.80	77.76	77.72	77.12	77.46	77.65	77.61	77.28

Table 18 : *Standard Errors of means of indices in each year of age*

Index	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Weight : height	0.12	0.11	0.16	0.20	0.25	0.24	0.17	0.14	0.18
Rohrer's	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ponderal	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sitting height : stature	0.11	0.15	0.15	0.14	0.10	0.08	0.11	0.09	0.09
Chest girth : stature	0.17	0.16	0.17	0.20	0.26	0.24	0.17	0.17	0.18
Chest depth : Chest breadth	0.30	0.25	0.32	0.22	0.25	0.25	0.24	0.23	0.30
Intermembral	0.21	0.23	0.25	0.26	0.20	0.26	0.21	0.25	0.22
Acromion : iliac	0.38	0.43	0.44	0.37	0.42	0.35	0.33	0.32	0.34
Androgeneity	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Calf girth : Chest girth	0.21	0.18	0.16	0.22	0.20	0.16	0.15	0.16	0.13
Upper arm girth : Chest girth	0.17	0.12	0.13	0.17	0.14	0.15	0.16	0.13	0.15
Upper arm girth : Calf girth	0.33	0.28	0.31	0.44	0.36	0.41	0.37	0.44	0.36
Cephalic	0.30	0.29	0.28	0.36	0.36	0.39	0.30	0.27	0.30

Table 19 : *Standard deviations of means of indices in each year of age*

Index	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Weight : height	1.16	1.09	1.62	2.01	2.51	2.37	1.69	1.44	1.83
Rohrer's	0.07	0.06	0.07	0.07	0.10	0.18	0.07	0.08	0.10
Ponderal	0.09	0.08	0.09	0.09	0.13	0.11	0.09	0.09	0.12
Sitting height : stature	1.10	1.52	1.46	1.41	1.04	0.82	1.11	0.91	0.93
Chest girth : stature	1.71	1.55	1.73	1.98	2.49	2.39	1.67	1.66	1.81
Chest depth : chest breadth	3.01	2.51	3.21	2.15	2.50	2.45	2.41	2.25	3.02
Intermembral	2.12	2.27	2.47	2.60	1.96	2.58	2.10	2.47	2.16
Acromion : iliac	3.79	4.27	4.42	3.73	4.24	3.52	3.29	3.15	3.37
Androgeneity	0.22	0.24	0.25	0.20	0.23	0.18	0.18	0.16	0.19
Calf girth : chest girth	2.15	1.80	1.63	2.24	2.01	1.65	1.58	1.69	1.37
Upper arm girth : chest girth	1.72	1.28	1.38	1.75	1.48	1.56	1.60	1.30	1.50
Upper arm girth : calf girth	3.34	2.88	3.13	4.47	3.67	4.18	3.77	4.43	3.64
Cephalic	2.98	2.86	2.83	3.56	3.58	3.87	3.98	2.67	2.95

However, the relative growth of chest during adolescent spurt in comparison to stature is more marked than the relative growth of weight in relation to height when the three dimensional nature of the body weight is considered. The continuous increase in the index values from 14+ to 19+ years reveals the growing importance of chest in relation to stature during middle and later phases of adolescence.

6. *Chest depth : Chest breadth index* (*Fig.* 38)

Chest circumference is otherwise relatively the sum total of chest breadth and chest depth and the proportional growth between them during adolescence reveals the shape of the chest. The values of index (Fig. 38) decreases continuously with the increase of age except between 13+ and 14+ years and 17+ and 18+ years where it displays slight increase. This is mainly due to relatively higher rate of growth in chest breadth than chest depth. It has already been seen in growth curves that the chest breadth shows greater velocities of increment than chest depth during adolescence. The relative growing importance of chest depth over chest breadth is shown by raising the index values.

7. *Intermembral index* (*Fig.* 39)

This index shows the relation between two extremities through age. Fluctuations of this index value are more observed in the earlier years of adolescence up to the adolescent spurt than in the later years. At 11+ and again at 14+ years the upper extremity length is relatively larger than lower extremity length but at 12+, 15+ and 16+ years the lower extremity is relatively larger over the upper extremity. It nearly reaches a stable relationship by about 17+ year after which there is very little relative increase of the lower extremity length.

8. *Acromion : Iliac index* (*Fig.* 40)

This index represents the shape changes in shoulder and hip breadth. Generally during adolescence the increase in the breadth of the hip and shoulder becomes more and more prominent than the upward increments in stature or other linear measurements. The values of acromion : iliac index show the following trends. While the shoulder breadth grows more rapidly in the earlier years of adolescence before the spurt, the hip begins to catch-up more and more from 16+ years onwards. During 14+ and 15+ years, the hip breadth dominates in growth but in the next year the shoulder breadth again goes ahead of it. As the sexual development of the male during adolescence is influenced by the androgenic hormones, it obviously leads to much greater growth of shoulder than that of hip. The proportionate growth of the two girdles can be

better understood by using the androgeneity index (Fig. 41). The index slopes down up to the 14+ year and more rapidly between 13+ and 14+ years ; it again speeds up during the spurt age and remains steady up to about 18+ year. It again shoots up in growth afterwards.

9. *Physical changes due to chest, arm and calf growth*

Study of proportional growth between girth measurements is equally important as they provide roundedness to shape changes. Here three such indices are dealt with such as, calf girth : chest circumference ; upper arm girth : chest circumference and upper arm girth : calf girth and changes due to them underlined. The growth of calf girth has a greater importance than chest girth in the initial and terminal ages of adolescence than in the other periods among the Bhil boys (Fig. 42). It begins to grow from 13+ yaer and again after 16+ year and shows a fall during the rest of the ages. Upper arm girth shows a different pattern and a steady rise in the curve indicates the growing importance of upper arm girth in relation to chest girth from 13+ year onwards. However, chest girth has shown its greater proportion of growth to upper arm girth from 11+ to 13+ years (Fig. 43). A more or less similar phenomenon is observed when the value of upper arm girth is expressed in terms of calf girth but towards the end of the range, that is, between 18+ and 19+ years of age, calf girth slightly compensates for its relative loss in size compared to upper arm girth (Fig. 44). From the study of these indices of girth measurements it is also clear that although arm, calf and chest girth all increase at each age, the ralative growth in arm girth, in general, is faster than either of the chest or calf girth measurements.

10. *Shape changes in head*

The cephalic index is a good measure for finding out shape changes in head. This index relates the length of the head to its breadth and spells out the degree of round headedness. The values of the index clearly show two cycles of change during the adolescent period atleast among the Bhil boys (Fig. 45). The proportion of head breadth increases between 11+ and 12+ years and abruptly decreases in the spurt age, again increases to have a second maximal at 17+ year of age and finally decreases from 18+ years.

SEXUAL DEVELOPMENT

The frequency distributions of the stages of development of genitals and pubic, facial and axillary hair in successive ages during adolescence indicate the nature of age variation among Bhil boys (Table 20 ; Fig.

Table 20 : Percentage of Bhil boys at each developmental stage of primary and secondary sexual characters by age

Pubertal Character	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Male genitals									
Stage-1	88	29	4	—	—	—	—	—	—
Stage-2	12	56	41	7	—	—	—	—	—
Stage-3	—	15	49	62	27	4	—	—	—
Stage-4	—	—	6	31	73	96	65	1	—
Stage-5	—	—	—	—	—	—	35	99	100
Pubic hair									
Stage-1	99	70	35	6	—	—	—	—	—
Stage-2	1	30	60	51	4	—	—	—	—
Stage-3	—	—	5	34	72	48	4	—	—
Stage-4	—	—	—	9	24	52	91	43	—
Stage-5	—	—	—	—	—	—	5	57	100
Facial hair									
Stage-1	100	100	95	69	15	6	—	—	—
Stage-2	—	—	5	31	85	93	87	14	—
Stage-3	—	—	—	—	—	1	13	86	100
Axillary hair									
Stage-1	100	100	100	85	56	33	—	—	—
Stage-2	—	—	—	15	44	66	97	48	1
Stage-3	—	—	—	—	—	1	3	52	99

46 to 49). The first sign of impending puberty in the adolescent Bhil boys is the enlargement of testes and scrotum (G2) which is observed at a mean age of 12.8 ± 0.77 years. They mature fully around 18.7 ± 0.75 years. The first appearance of scanty and pigmented hair at the base of pubes (PH2) is noticed at a mean age of 13.7 ± 0.83 years and reach to the adult pattern of distribution at a mean age of 19.0 ± 0.60 years. Thus there is a difference of more than a year, on the average, between the first appearance of pubic hair and first sign of genital development. Other stages of genitalia are also ahead of pubic hair stages by more than a year. The facial hair (FH2) development starts at a mean age of 16.3 ± 1.20 years and the adult pattern of distribution is reached by about the age of 18.9 ± 0.68 years, on the average. The presence of axillary hair (AH2) is observed at the mean age of 16.9 ± 1.10 years and reaches to maturity, simultaneously along with the pattern and development of facial hair by about 19.0 ± 0.61 years. The average Bhil boy thus takes about 6 years to reach adult stage in genitalia maturation and about 5 years to reach the adult pattern of pubic hair distribution after their first appearance. Furthermore, the average Bhil boy takes about 2.5 years to reach to the adult pattern of distribution of facial and axial hair development after their first transformation from unpigmented to pigmented hair (Table 21).

The average age and duration of the various stages of primary and secondary sexual characters are studied and the following observations were made. It is noted that the transition from stage 2 to stage 3 of of genitalia is relatively rapid which is a much longer period generally elapses between the attainment of stage 4 and the attainment of the adult size of the genitalia maturation (stage 5). However, in the pattern of pubic hair distribution the transition from stage 3 to stage 4 takes relatively rapid time over from stage 2 to stage 3 and stage 4 to stage 5. Considering both genitalia maturation and the development of pubic hair, the following is the sequence of appearance of various stages among Bhil boys.

Item	Mean age (Yrs.)
Genitalia-2 (enlargement of scrotum)	12.8
Pubic hair-2 (first appearane of pigmented hair)	13.7
Genitalia-3 (enlargement of penis)	14.2
Pubic hair-3 (slight curl and spread)	15.5
Genitalia-4 (further enlargement of penis and scrotum)	16.1
Pubic hair-4 (curly and more spread)	17.1

Table 21 : The average duration of various stages of primary and secondary sexual characters

Pubertal Character	Attainment of Mean age	SD	Period covered	Mean duration in years
Genitalia Maturation				
Stage-2	12.8	0.77	from stage-2 to stage-3	1.4
Stage-3	14.2	0.96	from stage-3 to stage-4	1.9
Stage-4	16.1	1.03	from stage-4 to stage-5	2.6
Stage-5	18.7	0.75	from stage-2 to stage-5	5.9
Pattern of pubic hair				
Stage-2	13.7	0.83	from stage-2 to stage-3	1.9
Stage-3	15.5	0.84	from stage-3 to stage-4	1.5
Stage-4	17.1	1.06	from stage-4 to stage-5	2.0
Stage-5	19.1	0.60	from stage-2 to stage-5	5.4
Pattern of facial hair				
Stage-2	16.3	1.11	from stage-2 to stage-3	2.6
Stage-3	18.9	0.68		
Pattern of axillary hair				
Stage-2	16.9	1.16		
Stage-3	19.0	0.61	from stage-2 to stage-3	2.1

Genitalia-5 (adult)	18.7
Pubic hair-5 (adult)	19.0

The genitalia takes longer time then pubic hair development to reach adult appearance. Thus, the pubertal devlopment in Bhil boys takes place in genitalia, pubic, facial and axillary hair in order of their sequence.

The average grades of development of the primary sexual characters represented by penis and scrotum, and that of secondary sexual characters represented by pubic, axillary and facial hair at each age has already been studied in terms of the final grades attained during 19+ year of age (Fig. 28). It has been observed that the development of the primary and secondary sexual characters has the lowest gradient among all organs and tissues. In other words the most rapid pubertal development becomes noticeable after the period of adolescent spurt, when gonadal and adrenal hormones combine with the growth hormone (Tanner, 1977).

CHANGES IN SUBCUTANEOUS FAT

The change in the thickness of subcutaneous fat is associated with the energy storage and expenditure during the process of adolescence. This is reflected by the curves of log transformation of the mean values for skinfold thickness in three anatomical sites (Table 22 ; Fig. 50 to 52) and more markedly for biceps skinfold thickness. There appears to be a small prepubertal fat wave at the age of 12+ years in both biceps and triceps skinfolds. But this is infact a recession of fat during 13+ years in both these thicknesses, perhaps reflecting a stress before adolescent spurt (Tanner, 1977). The subscapular fat does not grow in thickness during this age and do not show any recession among the adolescent Bhil boys. In all the three regions, the skinfold thickness shows the sharpest increase between 11+ and 12+ years and also during the adolescent spurt between 14+ and 15+ years. There is also a slight increment of fatfolds in all regions in the preceding year of 13+ to 14+ years, whereas, the triceps skinfold thickness slightly declines between 15+ and 16+ years. There is some increase of the fatfolds in the other two regions (biceps and subscapular) and more markedly on the biceps. This is followed by a steady growth during the rest of the period under study. The curves of the changes in skinfold thickness, particularly in the biceps region, show some resemblance with the growth curve of body weight and transverse measurements, except for apparent prepubertal fat wave during 12+ year. But the slope of the curve particularly in triceps and subscapular region is considerably gentler than the composite curves of body measurements.

Table 22 : Means, Standard Deviations and log valves of Skinfold thicknesses in each year of age

Skinfolds	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
					Means				
Biceps (mm)	3.60	3.78	3.63	3.75	4.02	4.29	4.33	4.44	4.76
Triceps (mm)	6.99	6.99	6.95	7.24	7.62	7.44	7.81	7.97	8.24
Subscapular (mm)	6.37	6.64	6.75	7.02	7.48	7.48	7.85	8.13	8.41
					Standard Deviations (+)				
Biceps (mm)	0.74	0.66	0.79	0.88	0.96	1.08	0.97	0.85	0.98
Triceps (mm)	1.26	1.05	1.44	1.26	1.73	1.28	1.29	1.36	1.67
Subscapular (mm)	1.18	1.09	1.46	1.38	1.93	1.24	1.42	1.14	1.35
					Log transforms				
Biceps	119.7	126.7	119.2	123.0	130.8	135.8	137.2	139.9	144.5
Triceps	170.1	170.7	169.8	172.6	174.7	174.7	176.9	178.1	179.4
Subscapular	163.8	167.6	167.7	169.0	173.2	174.4	177.0	179.4	181.1

SECTION SIX

NUTRITIONAL ASSESSMENT

The nutritional assessment of the Bhil boys has been done by using two methods, the diet recall and diet history. As the diet recall method has been generally used for one day only (24 hours), the diet history method has also been adopted to gather supplementary information regarding their pattern of food intake throughout the year and to locate the nature and amount of variation, if any. The details of the measuring techniques and formulation of the nutrient assessments are outlined in section two. The limitation of cross-sectional diet data for one day does not affect the present study because of routine nature of dietary intake among the Bhil boys.

Diet history

Bhils of all ages in the Udaipur district of Rajasthan are generally habituated to take two major meals a day, the one in the morning and the other in the evening besides taking seasonal fruits or groundnuts and *gur* (jaggery) between these meals. Only a few persons, about 15% of the subjects take tea or milk in the morning in addition. The usual items of the meals include a cereal, such as maize or wheat ; a pulse, generally black gram or Bengal gram ; a vegetable, mostly leafy vegetables and roots or tubers. They add to this some kind of animal protein atleast once in a week but not more frequently. They take the morning meal between 9 and 10 a.m. and the evening meal around 6 to 8 p.m. The Bhils depend mainly on the foods which they cultivate in their farms. *Makki roti* (bread made out of maize flour) and *urad dal* (black gram) are the chief sources of cereal food all through the year. Wheat is also commonly used as a substitute for maize. Bengal gram is the usual substitute for black gram. Occasionally they also take rice. They also consume at times a fermented gruel namely *rab*, prepared from broken grains and sour buttermilk as a substitute for the morning meal. The type of *subji* (vegetable) they take varies with season. They generally repeat the same menu in their morning and evening meals.

The usual leafy vegetables are fenugreek leaves, colocasia leaves, carrot leaves, cabbage, parwar sag (Trichosanthus dioica) and tamarind leaves. Among roots and tubers, potato, onion, carrot and colocasia

are usually consumed. Among other vegetables, they eat brinjal, beans, cluster beans, lowki (Layanaria vulgaris), pumpkin, tomato green, ridge gourd, bitter gourd, ladies fingers and tinda (Citrullus vulgaris).

Condiments and spices such as chillis, coriander, garlic, ginger fresh and turmeric are generally used in cooking. They use either groundnut oil or mustard oil in all preparations.

The Bhils of the study area consume plenty of seasonal fruits between their meals. The easily available fruits are zizyphus (zizyphus jujuba), ripe mahua (Bassia longifolia), ripe papaya, ripe mango, country guava, jambu fruit, wood apple and amla (emblica officinalis).

It has also been observed from repeated interviews and through the diet survey that the subjects of this study as well their family members regularly consume some amounts of groundnuts and *gur* (jaggery).

Bhils are non-vegetarian too and often (atleast once in a week on an average) consume various types of meat obtained through hunting or other sources like rearing goats and sheep etc.

There are about half-a-dozen local festivals throughout the year in addition to occasions such as marriage feasts and other ceremonial feasts. The most important of these is '*Gouri*' festival during March and April, and Diwali celebration during September and October. There are also a few seasonal fairs including that of holi, the spring festival. In all these occasions, they generally feast on non-veg of some kind and other preparations like rice puddings and also various types of cakes. The elder members of the tribe drink '*mahua*' (alcohol prepared from mahua flowers). However, the adolescent boys included in the present study are not found to share such drinks.

Diet recall

The average daily intake of essential nutrients of Bhil boys (Table 23) shows that except those aged 18+ and 19+ years, the food intake of adolescent boys of any age does not meet the daily requirement of calories as recommended by the Nutrition Expert Group of ICMR (1968). However, the mean units of calorie intake rises steadily in each successive year from 11+ to 19+ years except in 14+ and 17+ years.

The mean consumption of protein, fat, calcium, thiamine and riboflavin, however, appear to be rather adequate in terms of the daily requirements prescribed by ICMR (1968). It appears that Bhil boys consume relatively large amounts of thiamine. This is obviously due

Table 23 : Average daily intake of nutrients by Bhil boys aged 11+ to 19+ years (one day diet survey)

Age in Years	Calories Mean	Proteins (g) Mean	Fat (g) Mean	Calcium (mg) Mean	Iron (mg) Mean	Thiamine (mg) Mean	Riboflavin (mg) Mean
11+	1546	50	21	259	23	1.56	0.63
12+	1738	55	27	274	22	1.78	0.64
13+	1959	62	37	319	25	2.08	0.73
14+	1866	62	34	328	22	1.87	0.72
15+	2079	69	36	387	36	1.82	0.82
16+	2224	75	44	351	32	2.46	0.86
17+	2213	71	42	346	38	2.49	0.76
18+	2817	91	55	502	35	2.81	1.09
19+	3100	98	64	666	37	2.56	1.45

Table 24 : Percent frequency distribution of Protein — Caloric malnutrition by age

Category	Age in Years								
	11+	12+	13+	14+	15+	16+	17+	18+	19+
Caloric adequacy and protein adequacy	12	8	16	16	32	28	36	68	80
Caloric inadequacy and protein inadequacy	80	76	76	60	60	64	52	32	20
Caloric and protein inadequacy	8	16	8	24	8	8	12	nil	nil
Caloric adequacy and protein inadequacy	nil	nil	nil	nil	nil	nil	nil	nil	nil

Table 25 Diet composition of Bhil boys for age-group 11-12, 13-15 and 16-19 years tn a day.

Details of food	Age group 11-12 (gm)	13-15 (gm)	16-19 (gm)
CEREALS : Maize	299	339	430
Wheat	35	45	29
Rice	7	8	8
PULSES :	42	40	46
Green leaf vegetables	8	5	16
Other vagetables (including roots and tuber)	46	105	137
Fruits	53	82	96
Milk and milk products	22	32	34
Fats and oils	9	11	11
Flesh foods	19	26	32
Sugar and Jaggery	37	36	78
Condiments	8	10	13
Groundnuts	—	15	54

to their routine consumption of the cereal maize and pulse-blackgram. The frequency distributions of different levels of protein-calorie adequacy (Table 24) display that most of Bhil boys in age-groups from 11+ to 17+ years suffer from a gross calorie deficiency in their diet.

The composition of diet of adolescent Bhil boys (Table 25) is again not adequately balanced as per ICMR standards. The low calorie content in their diet especially in the lower age-groups is atleast partly explained by the following observations.

The Bhil boys are subjected to the strain of walking long distances to attend schools. They leave for schools in the morning after having mostly cold food cooked on the previous day. They take the next meal only in the evening when they come back from schools. It has been observed that the boys attending schools do not usually take any tiffin during the day. They are deprived of taking the normal meal in the morning with the members of the family except on holidays. However, they take considerably more quantities of food in the evening than other members of the family. On the other hand, older Bhil boys who have left schools are in a better position to satisfy their dietary needs than the adolescent boys of younger age-groups. They consume relatively large quantities of available food during major meals and also fruits and jaggery during the day time.

The observed larger concavity in the growth curves from 11+ to 14+

years for many growth characteristics in the present study is obviously related to the prolonged caloric deficiency in the age of most rapid growth during early adolescence. The present findings are particularly important because the data on the influence of poor nutrition on the adolescent spurt are otherwise rather meagre. The calorie requirement increases during adolescence (Heald, Reminall and Mayer, 1969) in parallel with increased growth during the adolescent spurt. Lack of sufficient calories may result either in a smaller or indistinct adolescent spurt or a delay in the age of spurt. Bhil boys of the present investigation, who are only deficient in required calories before adolescent spurt age, however, exhibit a sufficiently marked spurt, though delayed. The fat fold recession before the spurt age indicates the assimilation of fat when they are really in scarcity of calories.

Surveys conducted by National Institute of Nutrition, Hyderabad have also shown that in most of the Indian populations there is a de-deficiency of calories and not proteins. Gopalan *et al* (1971) suggested that the supplementation of diet should be directed towards providing more calories and not in the distribution of protein concentrates.

SECTION SEVEN

SUMMARY AND CONCLUSION

The present cross-sectional study describes pattern of growth in 23 body dimensions, physical changes involving thickness of subcutaneous fat on 3 anatomical sites, body shapes as indicated by indices of these measurements and stages of pubertal development, and quantitative assessment of nutritional status among 900 adolescent Bhil boys aged 11+ to 19+ from various locales in Udaipur district of Rajasthan. Altogether 900 boys attending or having passed curriculum distributed equally in nine yearly age groups have been subjected to measurement and relevant observation. The major findings of the study are summarised as follows.

1. All the 23 body dimensions of adolescent Bhil boys show progressive increase in successive years from 11+ to 19+ years. The magnitude of annual increments and the pattern of variation or rhythm of these increments, however, differ from one measurement to the other. But still they can be conveniently grouped according to the patterns of their characteristic growth curves.

2. The transverse and circumferential measurements on the trunk and limbs as also the body weight display significant yearly increments throughout the adolescent period or a major part of it. The growth curves of the traits are concave up to the 15+ year followed by a nearly straight line. The other measurement, the head and neck height which is linear shows similar growth trend. The growth rate in such measurements reaches its maximal during 14+ to 15+ years, which shows a marked adolescent spurt, but the spurt of biiliocristal breadth spreads from 13+ to 15+ years. This is followed by a general decline of growth rate until the 18+ year after which there is again an acceleration in growth. The velocity curves of these traits also tend to display a minor peak earlier than the spurt age.

3. The growth curves of linear measurements of stature, trunk and limbs are sigmoid in shape. They follow the left side concavity of the transverse measurements and weight up to 15+ year, but afterwards become convex, indicating slowing down of yearly growth rate from about 17+ year. The concavity is, however, shallower in the case of limb lengths. The growth rates beyond 17+ year are not large enough to

reveal significance in a sample of 100 subjects per year, but they are consistent with the expected continuation of slow growth for sometime.

4. The adolescent spurt in stature and trunk length is clearly located during 14+ to 15+ years, but in sitting height and upper extremity length the spurt is smoothened and prolonged from 13+ to 15+ years as in biiliocristal breadth. The lower extremity length also displays two peaks of growth velocity between 12+ and 13+ years and between 14+ and 15+ years. The difference between trunk height and sitting height in this respect is attributed to segmental growth of head and neck height with respect to the latter. The sitting height and trunk height both show a clear second peak of growth velocity between 16+ and 17+ years along with breadth measurements.

5. The segmental growth has also shown significant increase in stature in the initial years of adolescence among the Bhil boys and it is due more to the growth of lower extremity length and in the later years it is due more to the growth of trunk.

6. The results of the present study confirms the distinctive growth patterns of cephalo-facial mueasurements in comparison with non-cephalic measurements. The growth curves of almost all characters indicate nearly uniform and small rate of growth. Significant annual increments are obtained only during small parts of the adolescent age range for most of the traits. The growth rates of head circumference appear to be the largest, but the spurt age is extended from 13+ to 15+ years.

7. The most general phenomenon in the present data is a slight increase of growth rate at the beginning of adolescence in Bhil boys, followed by a decline before a sharp adolescent spurt. The most abrupt decline of growth rate appears to occur just after the spurt age. Characters with continuous growth generally show a second acceleration towards the end of the period.

8. The percentage of growth attained from 11+ to 19+ years is highest in weight, followed by that of the breadths and girths. The growth attained by linear dimensions occupies an intermediate position while the head and face measurements come in the last in order. There is a much greater amount of growth in hip breadth, chest breadth, lower extremity, some facial measurements and head and neck height before the 14+ year than later. The girth measurements attain much higher rank in growth rate towards the end of the adolescent period than the beginning. The linear measurements show the least amounts of growth after 17+ year of age.

9. The measurements conform to the scheme of maturation suggested earlier. The head, face, linear, girths and breadths and body weight are near to their adult size in the order of their sequence. The pubertal development is behind the maturation of other body dimensions. Furthermore, there may also be an antero-posterior gradient in head measurements. The growth of lower parts of face appear to lag behind that of the bizygomatic breadth. Again, development of genitalia is in advance over secondary sexual characters, except in initial years of adolescence and pubic hair appears earlier than facial and axillary hair.

10. There is no definite pattern of change in the variability of the measurements through age as has been observed in Bhil boys during adolescence. A comparison of the variance at yearly age groups shows that somatic variation among Bhil boys is smaller in almost all age groups except in 18+ and 19+ years. The centile curves and frequency distributions of the traits display a greater homogeneity of adolescent Bhil boys of all ages.

11. The comparative study of heights and weights of Bhil boys with the available specific Indian groups, reveals that Bhil boys could only be compared with the populations like Bods of Ladakh and Munda/Oraons of Chota Nagpur, but not with the Punjabi Khatris and Maharashtra Brahmins. In height and weight Bhil boys show closer resemblance to semi-urban and rural boys of South India.

12. The growth patterns of Bhil boys during adolescence show greater resemblance with boys of corresponding ages belonging to tribal and poor populations of different regions of the world than with the caucosoid samples. Their mean weight for height at 16+ year is smaller than most other available data except from the Lumi boys of New Zealand, Quechua boys of Peru and Hutu tribal boys of Africa.

13. On the average, the pubertal development in the Bhil boys such as, (genitalia, pubic, facial and axillary hair) mainly takes place in order of their sequence. The period and duration of average developmental stages of the above primary and secondary sexual characters in order of their sequence are from 12.8 $\pm$ 0.77 to 18.7 $\pm$ 0.75 years ; 13.7 $\pm$ 0.83 to 19.0 $\pm$ 0.60 years ; 16.3 $\pm$ 1.1 to 18.9 $\pm$ 0.68 years ; and 16.9 $\pm$ 1.2 to 19.0 $\pm$ 0.61 years respectively after their first sign of appearance. Thus an average Bhil boy takes about 6 years to reach the adult stage in genitalia maturation, about 5 years to reach the adult pattern of pubic hair distribution, about 2.5 years to reach the adult pattern of distribution of facial and axillary hair development after their first transformation from unpigmented to pigmented hair.

14. The development of the primary and secondary sexual characters has the lowest gradient among all organs and tissues (growth characteristics). This observation is in conformity with the earlier observations made by Scammon (1927) and Tanner (1962).

15. A small pre-pubertal fat wave is observed at the age of 12+ year in both biceps and triceps skinfolds, but this infact reflects a greater use of energy store and recession of fat during 13+ year as a result of stress preceding the spurt. The subscapular skinfold does not show this recession. The skinfold thickness increases most markedly between 11+ and 12+ years and between 14+ and 15+ years.

16. The average somatometric indices through age of Bhil boys are examined to locate the changes in shape and relative growth of pairs of measurements during adolescence. The most striking physical change during adolescence is the transformation from linearity to bulkiness. This is clearly reflected by the mean curves of height : weight index, Rohrer's index and Ponderal index. It is more apparent during and after the spurt age when due allowance is given to the three dimensional character of weight. The predictability of the weight from height gradually declines after the spurt age due to the beginning of proportionately greater growth in weight.

17. The shape changes that occur in linear body segments, chest, shoulder and hip, extremities and head during adolescence are observed thoroughly through the study of altered ratios of different body dimensions.

18. The data on 'diet history' of the tribe concerned, suggest the nature of variation in their diet throughout the year or seasons. The quantitative data on nutritional assessment through 'diet recall' reflect a gross deficiency of calorie intake in the Bhil boys up to 17+ year and particularly from 11+ to 14+ years. Howerver, the nutritional data indicate higher consumption of other nutrients like proteins, fats, calcium, iron and other vitamins like thiamine and riboflavin. These suggest that the prolonged deficiency of caloric intake in the preceding years is reflected in the delayed but sharp adolescent spurt. The fatfold recession just before the spurt age indicates the assimilation of body fat during deprived conditions.

Thus, the present analysis of cross-sectional data on adolescent growth, maturation and nutrition of the adolescent Bhil boys help to locate the present conditions of their health apart from providing normative standards for the population. They also strengthen the suggestion of the role of specific nutrients in specific growth periods. The results of the study emphasize the need for further comparative studies on specific populations in India.

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FIGURES

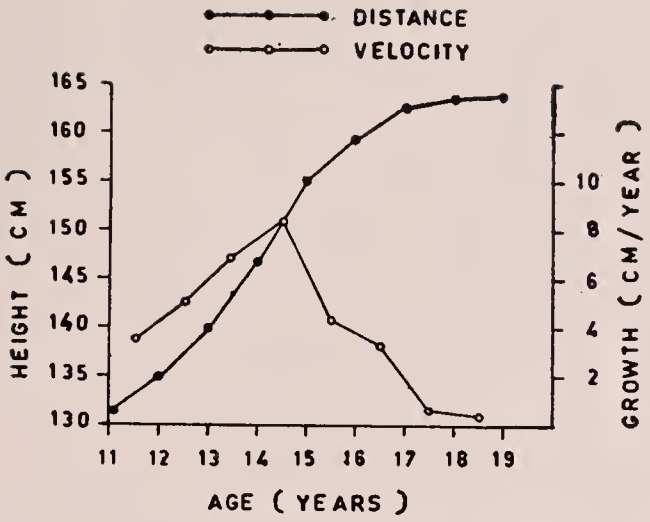

FIG. 2 DISTANCE AND VELOCITY CURVES OF HEIGHT

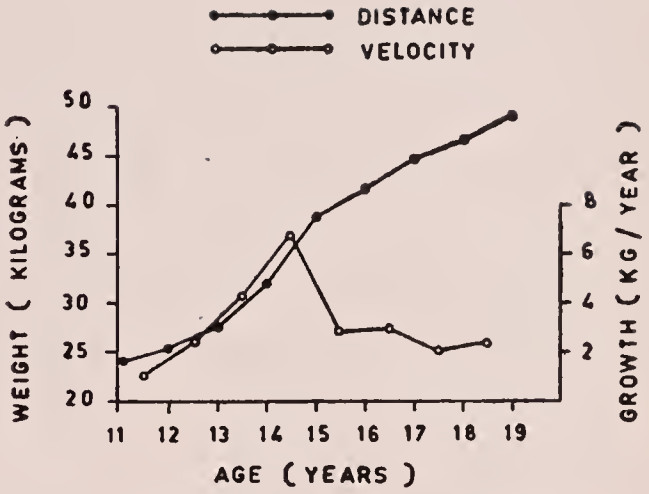

FIG. 3 DISTANCE AND VELOCITY CURVES OF WEIGHT (KILOGRAMS)

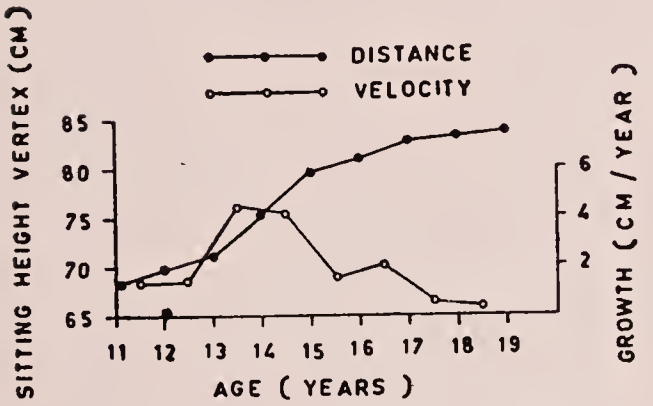

FIG. 4 DISTANCE AND VELOCITY CURVES OF SITTING HEIGHT VERTEX

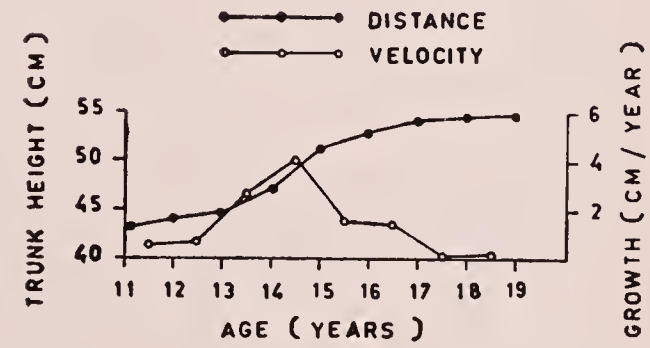

FIG. 5 DISTANCE AND VELOCITY CURVES OF TRUNK HEIGHT

FIG. 6 DISTANCE AND VELOCITY CURVES OF UPPER EXTREMITY LENGTH

FIG. 7 DISTANCE AND VELOCITY CURVES OF LOWER EXTREMITY LENGTH

FIG. 8 DISTANCE AND VELOCITY CURVES OF BIACROMIAL BREADTH

FIG. 9 DISTANCE AND VELOCITY CURVES OF BI-ILIOCRISTAL BREADTH

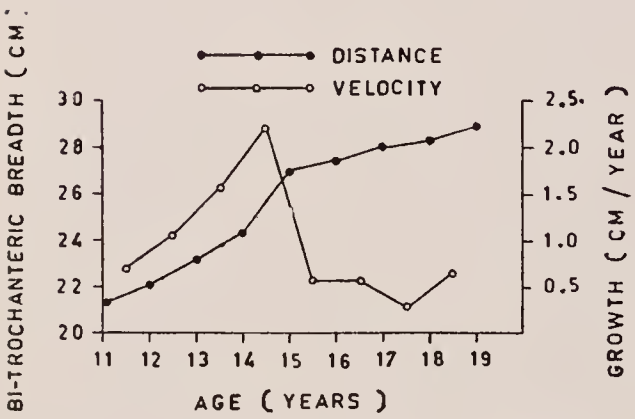

FIG. 10 DISTANCE AND VELOCITY CURVES OF BI-TROCHANTERIC BREADTH

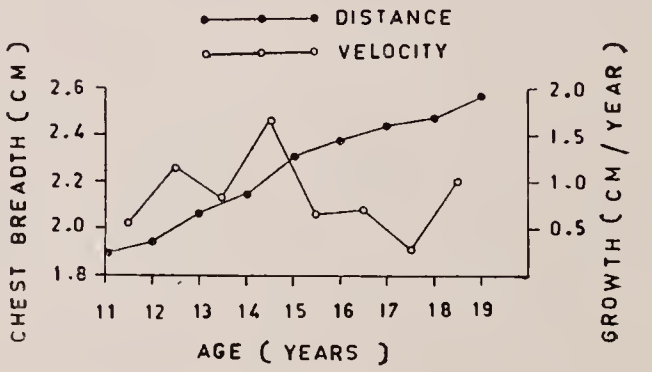

FIG. 11 DISTANCE AND VELOCITY CURVES OF CHEST BREADTH

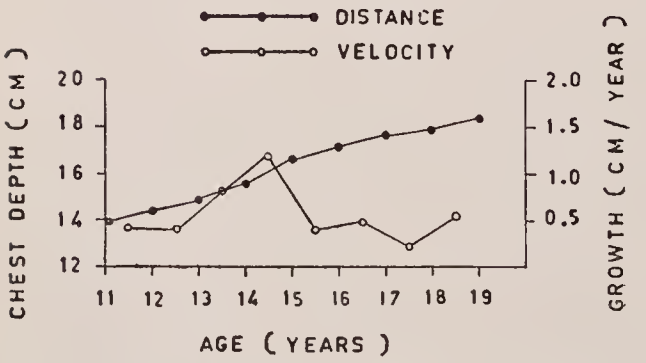

FIG. 12 DISTANCE AND VELOCITY CURVES OF CHEST DEPTH

FIG. 13 DISTANCE AND VELOCITY CURVES OF UPPER ARM GIRTH

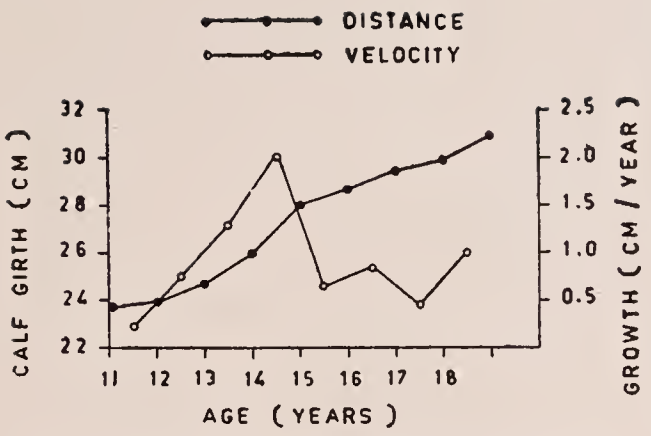

FIG. 14 DISTANCE AND VELOCITY CURVES OF CALF GIRTH

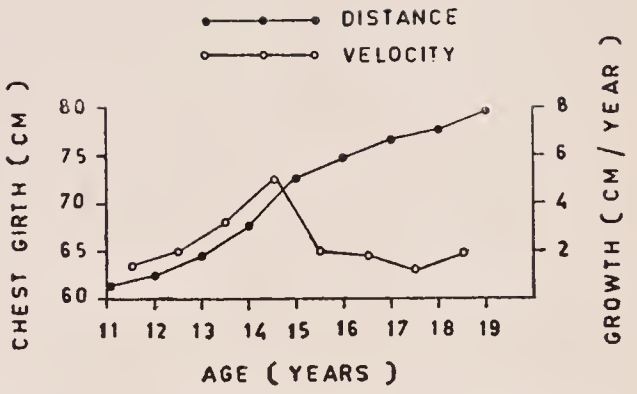

FIG. 15 DISTANCE AND VELOCITY CURVES OF CHEST GIRTH

FIG. 16 DISTANCE AND VELOCITY CURVES OF HEAD AND NECK HEIGHT

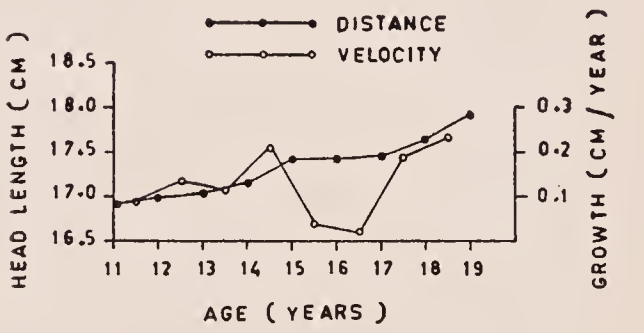

FIG. 17 DISTANCE AND VELOCITY CURVES OF HEAD LENGTH

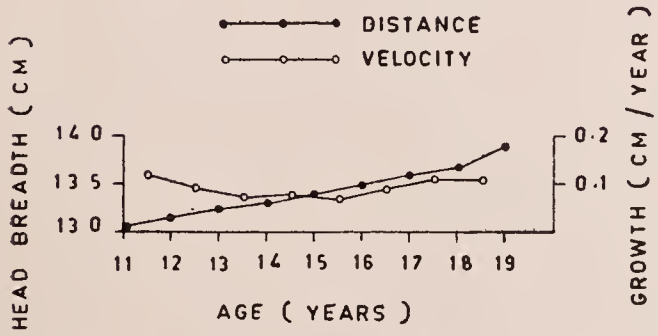

FIG. 18 DISTANCE AND VELOCITY CURVES OF HEAD BREADTH

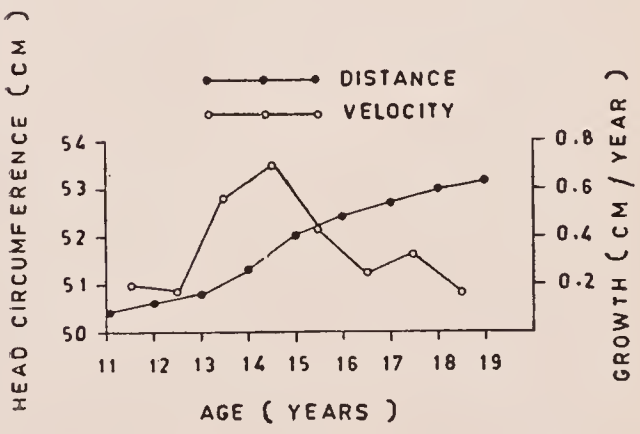

FIG. 19 DISTANCE AND VELOCITY CURVES OF HEAD CIRCUMFERENCE

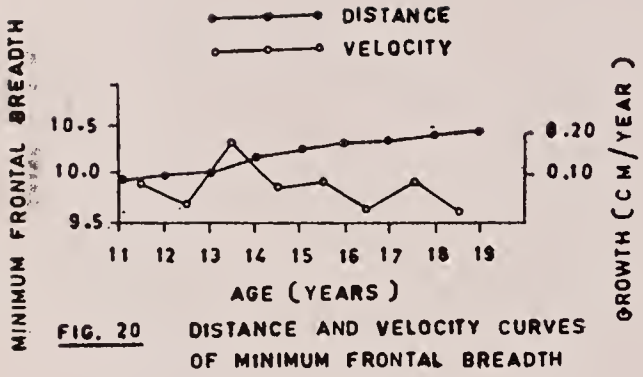

FIG. 20 DISTANCE AND VELOCITY CURVES OF MINIMUM FRONTAL BREADTH

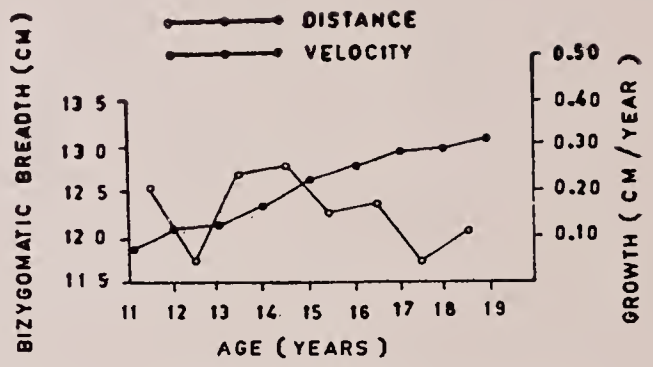

FIG. 21 DISTANCE AND VELOCITY CURVES OF BIZYGOMATIC BREADTH

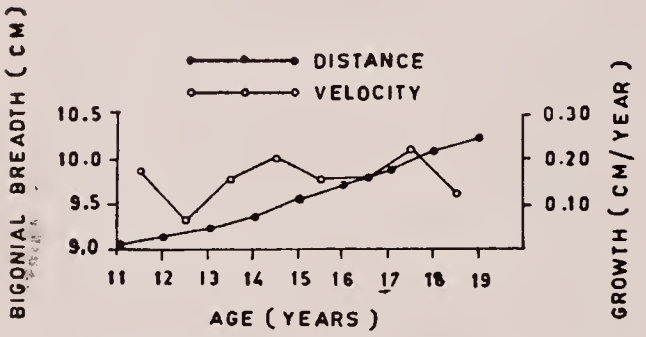

FIG. 22 DISTANCE AND VELOCITY CURVES OF BIGONIAL BREADTH

FIG. 23 DISTANCE AND VELOCITY CURVES OF TOTAL FACIAL HEIGHT

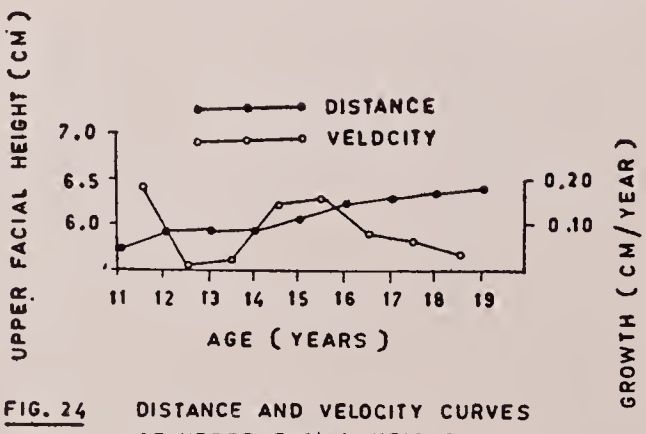

FIG. 24 DISTANCE AND VELOCITY CURVES OF UPPER FACIAL HEIGHT

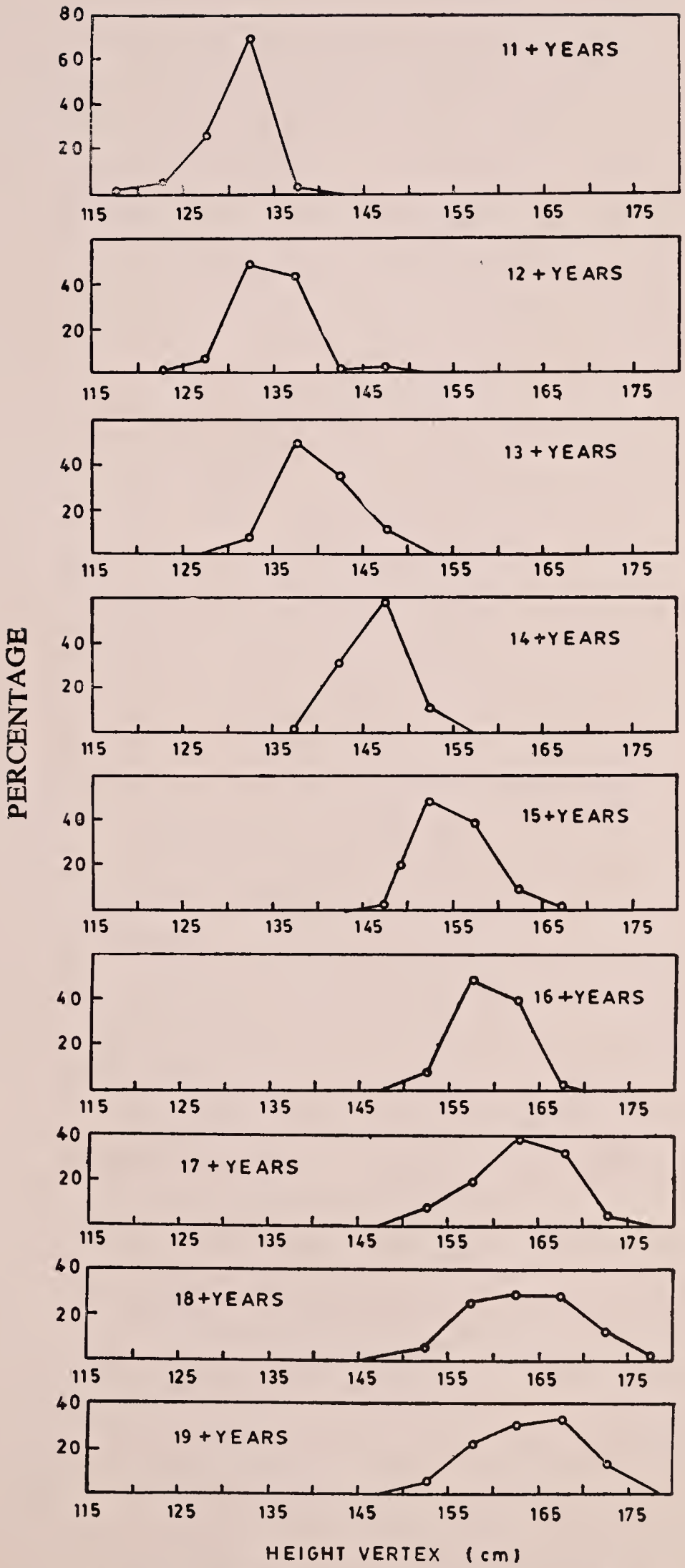

Fig. 25. Percentage distribution of hight vertex of Bhil boys in each year of age.

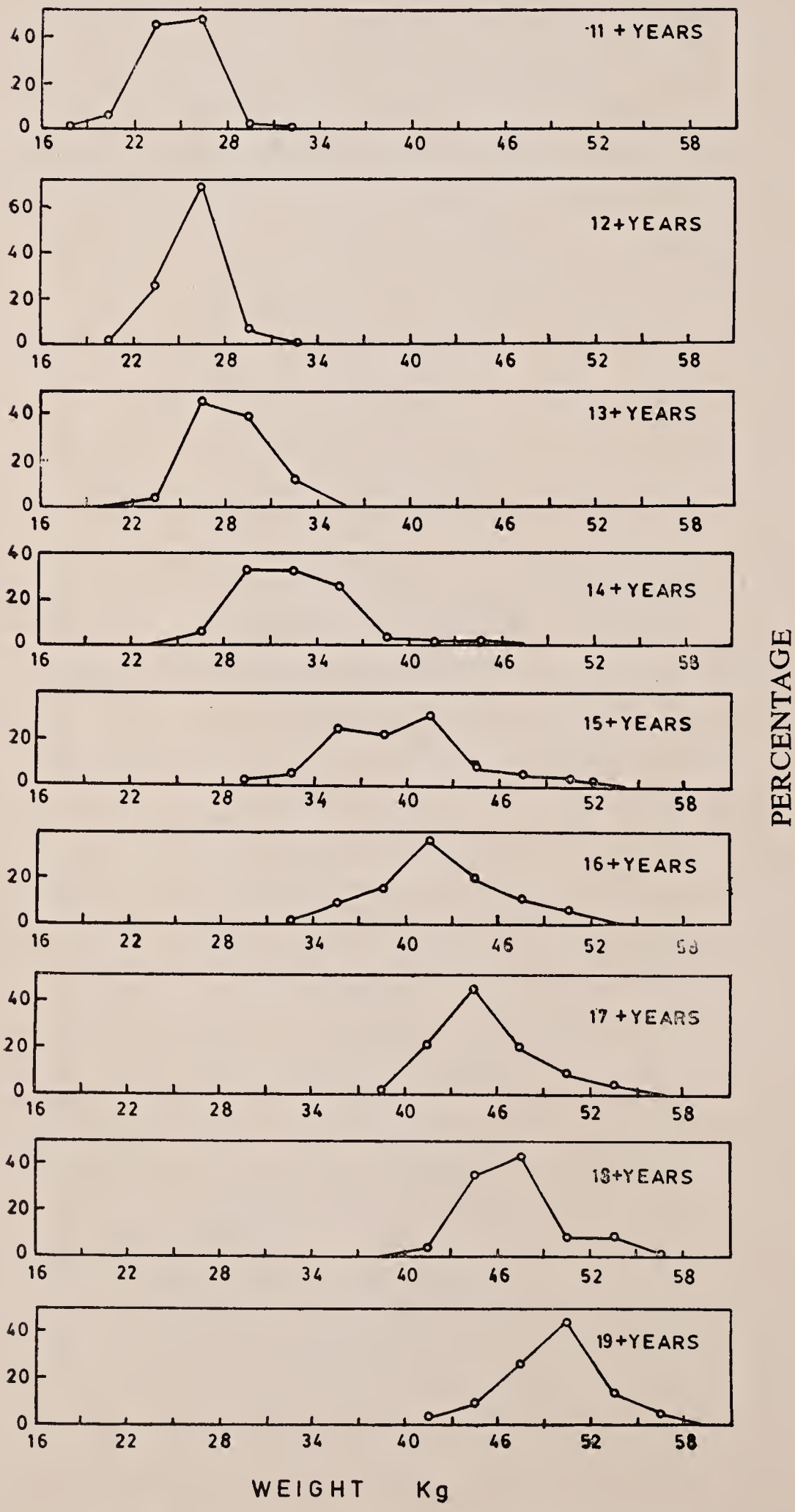

Fig. 26 Percentage distribution of Weight of Bhil boys in each year of age.

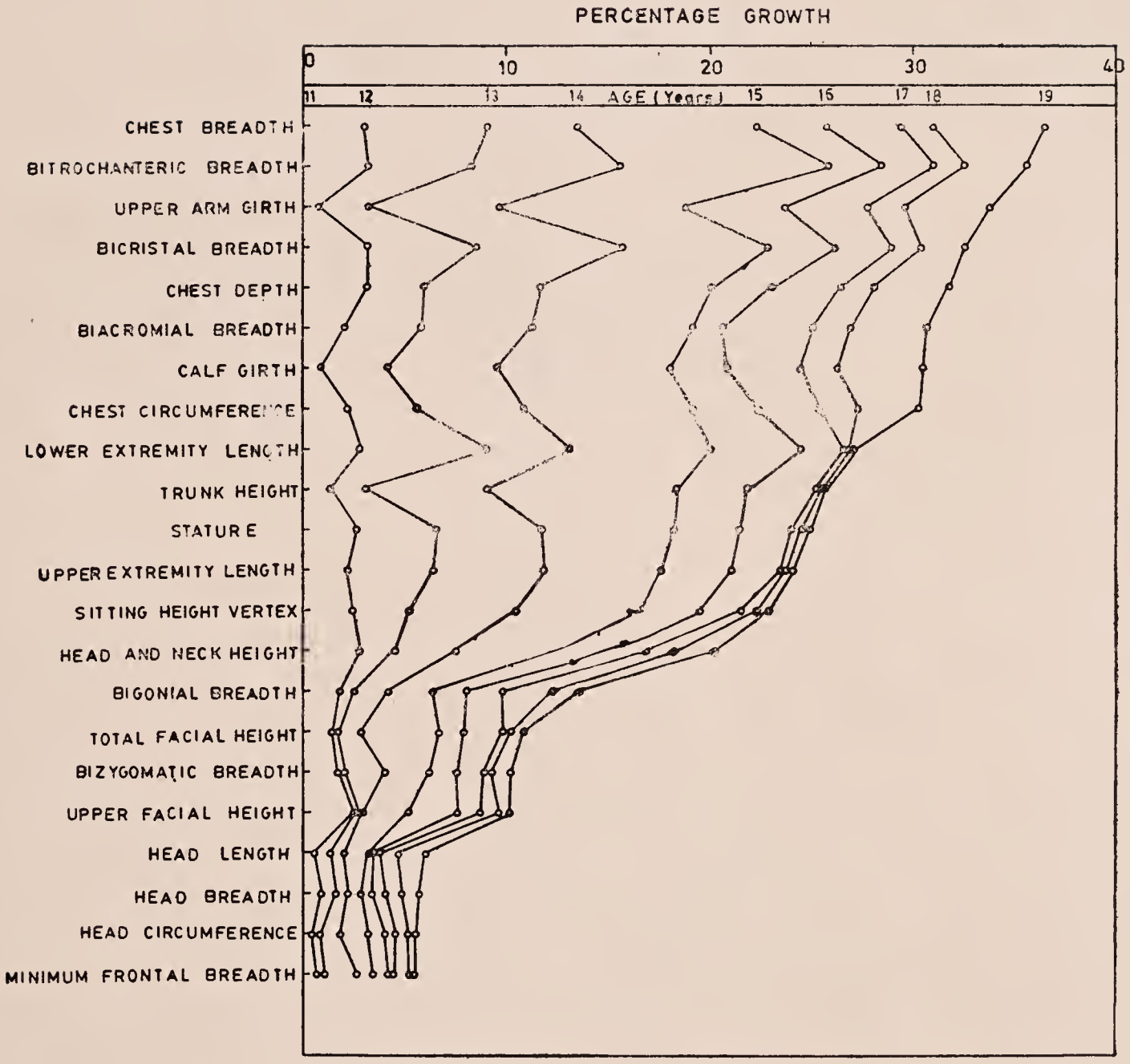

Fig. 27. Percentage growth profiles of various body dimensions.

HEAD MEASUREMENTS

1. Head Length
2. ,, Breadth
3. ,, Circumference

FACIAL MEASUREMENTS

1. Bigonial Breadth
2. Total Facial Height
3. Bizygomatic Breadth
4. Upper facial height
5. Minimum frontal breadth

LENGTH MEASUREMENTS

1. Lower extremity length
2. Trunk height
3. Upper extremity length
4. Sitting height Vertex
5. Head & neck height
6. Strature

BREADTH & GIRTH

1. Chest breadth
2. Upper arm girth
3. Biiliocristal breadth
4. Chest depth
5. Biacromial breadth
6. Calf Girth
7. Chest circumference

VOLUME

1. Body weight

PRIMARY & SECONDARY SEXUAL CHARACTERS

1. Axillary hair
2. Facial hair
3. Pubic hair
4. Male genitals

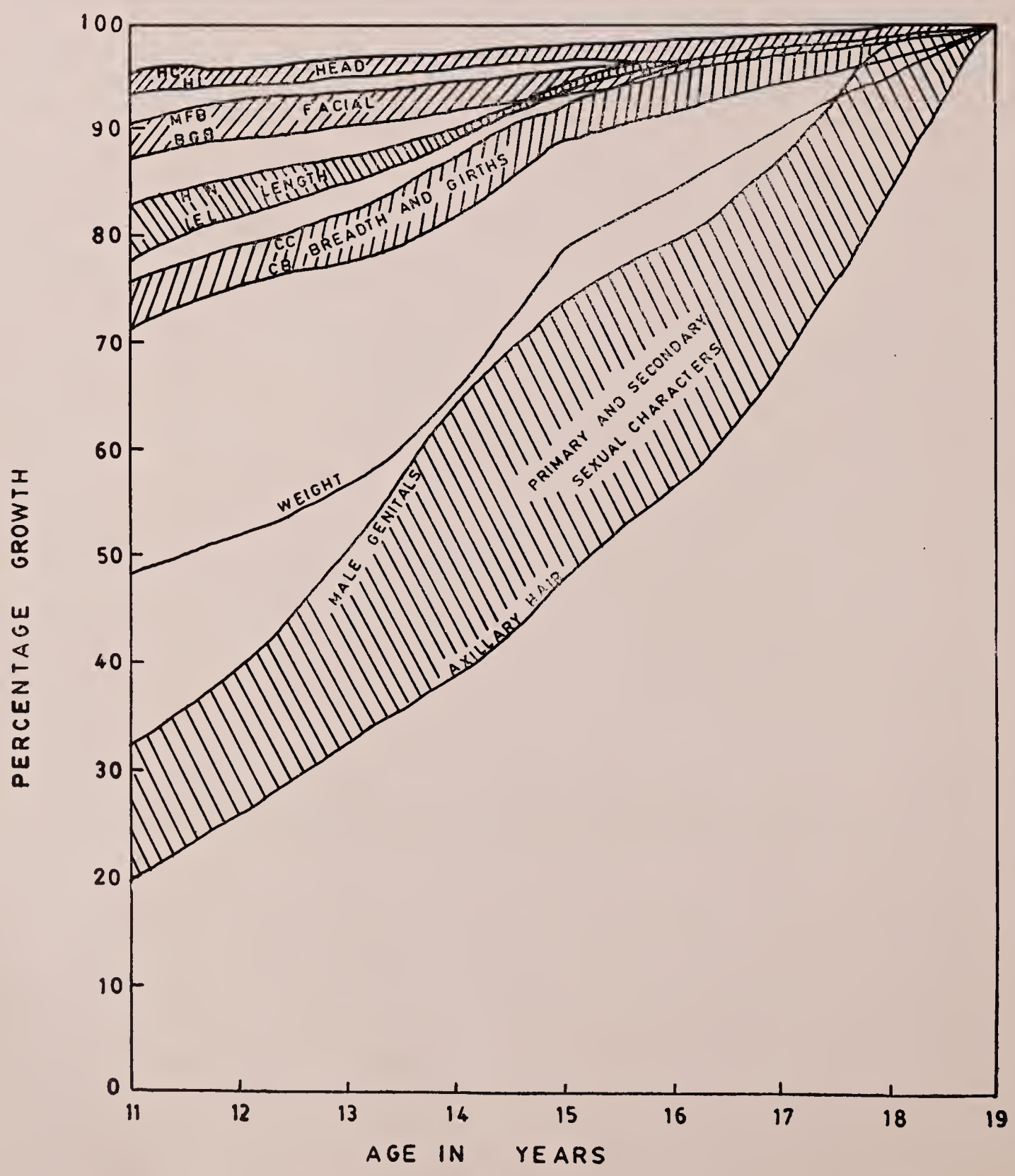

Fig. 28. Curve of growth and development of different system of the body.

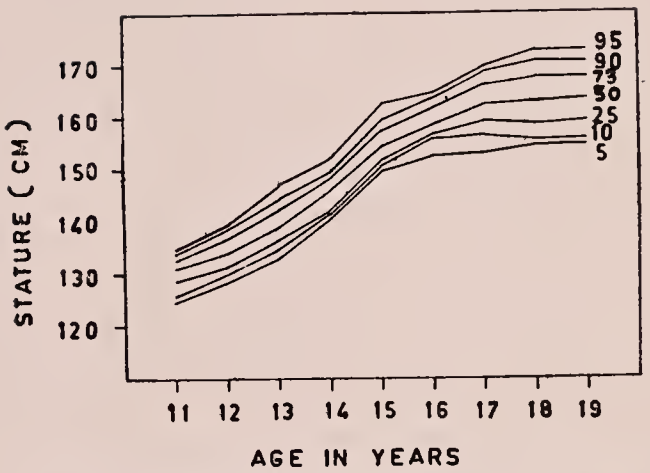

FIG. 29. SELECTED PERCENTILES OF STATURE DISTRIBUTION

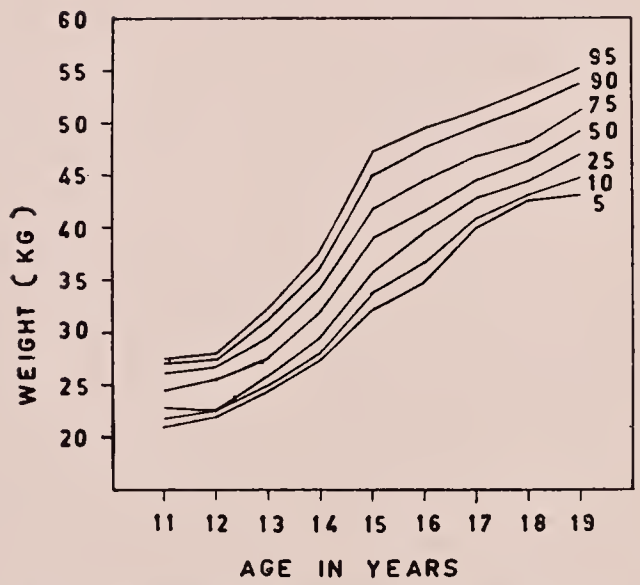

FIG. 30. SELECTED PERCENTILES OF WEIGHT DISTRIBUTION

		Strature	*Weight*
1	Bhil of Rajasthan	159.5	41.8
2	Punjabi Khatries	165.6	48.8
3	Maharastrian Brahmins	161.7	46.8
4	Bods of Ladkh	157.9	43.9
5	Indian Boys (National)	159.5	43.2
6	Indian Wel-off (Boys)	163.8	59.6
7	Rajasthan Boys	159.8	43.3
8	Uttarpradesh Boys	160.0	44.3
9	Madhya Prodesh Boys	159.7	65.0
10	West Bengal Boys	164.0	48.7
11	Punjab Boys	163.6	47.5
12	Delhi Boys	160.9	46.7
13	Orrisa boys	162.7	45.9
14	Jammu & Kashmir Boys	161.8	44.5
15	Aadhra Pradesh Boys	160.5	44.0
16	Kerala Boys	157.1	40.6
17	Tamilnadu Boys	157.6	40.6
18	Nagpur Boys	157.5	40.8
19	Puna Boys	158.5	40.8
20	Varanasi Boys	162.0	47.7
21	Chittoor Urban Boys	157.0	39.7
22	Chittoor Rural Boys	156.9	37.7
23	South Indian Urban Boys	161.1	43.9
24	South Indian Semi Urban Boys	157.6	40.4
25	South Indian Rural Boys	155.4	38.7

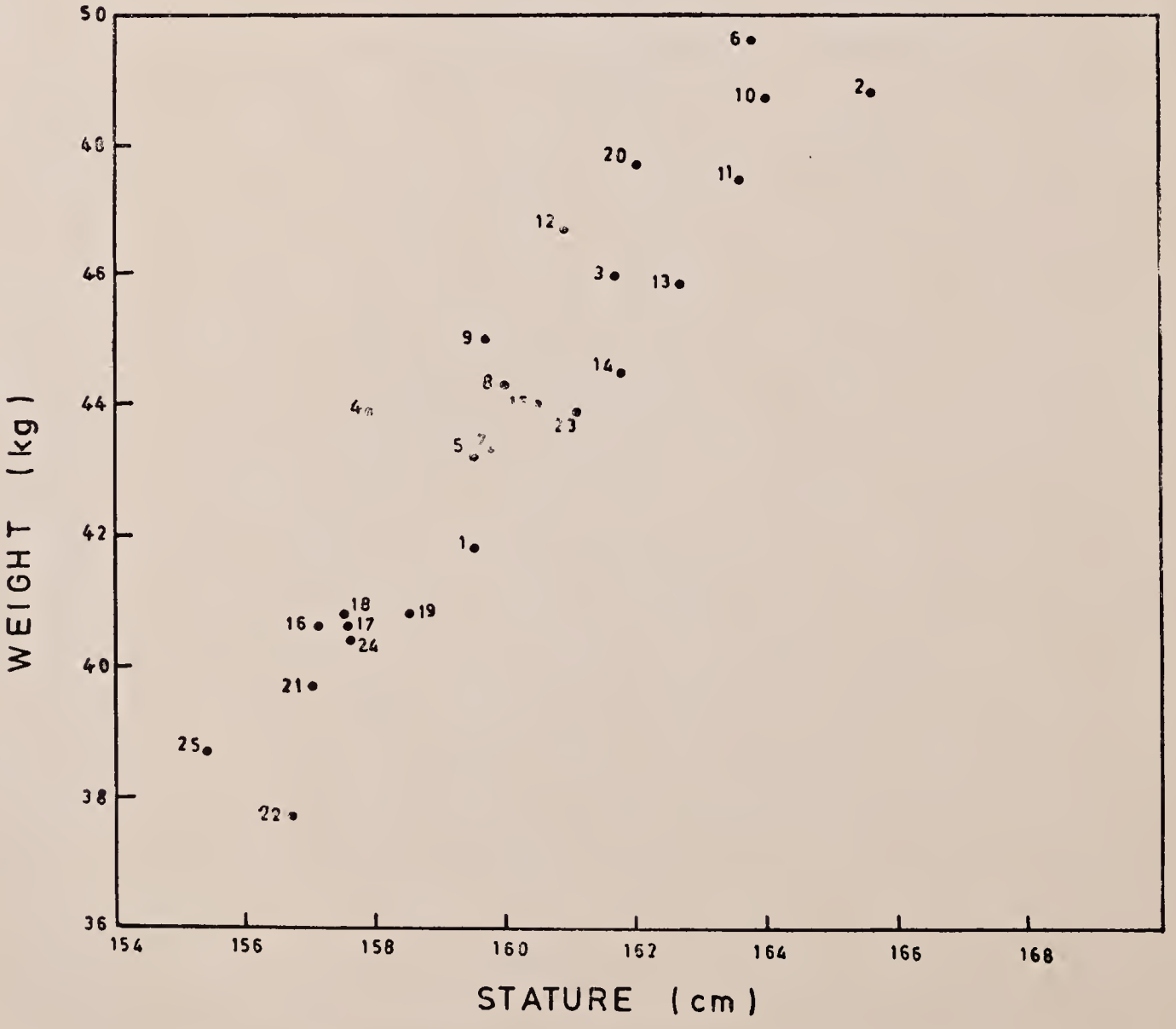

Fig. 31 Weight means plotted against height means for 16 years old boys by region and socio-economic class

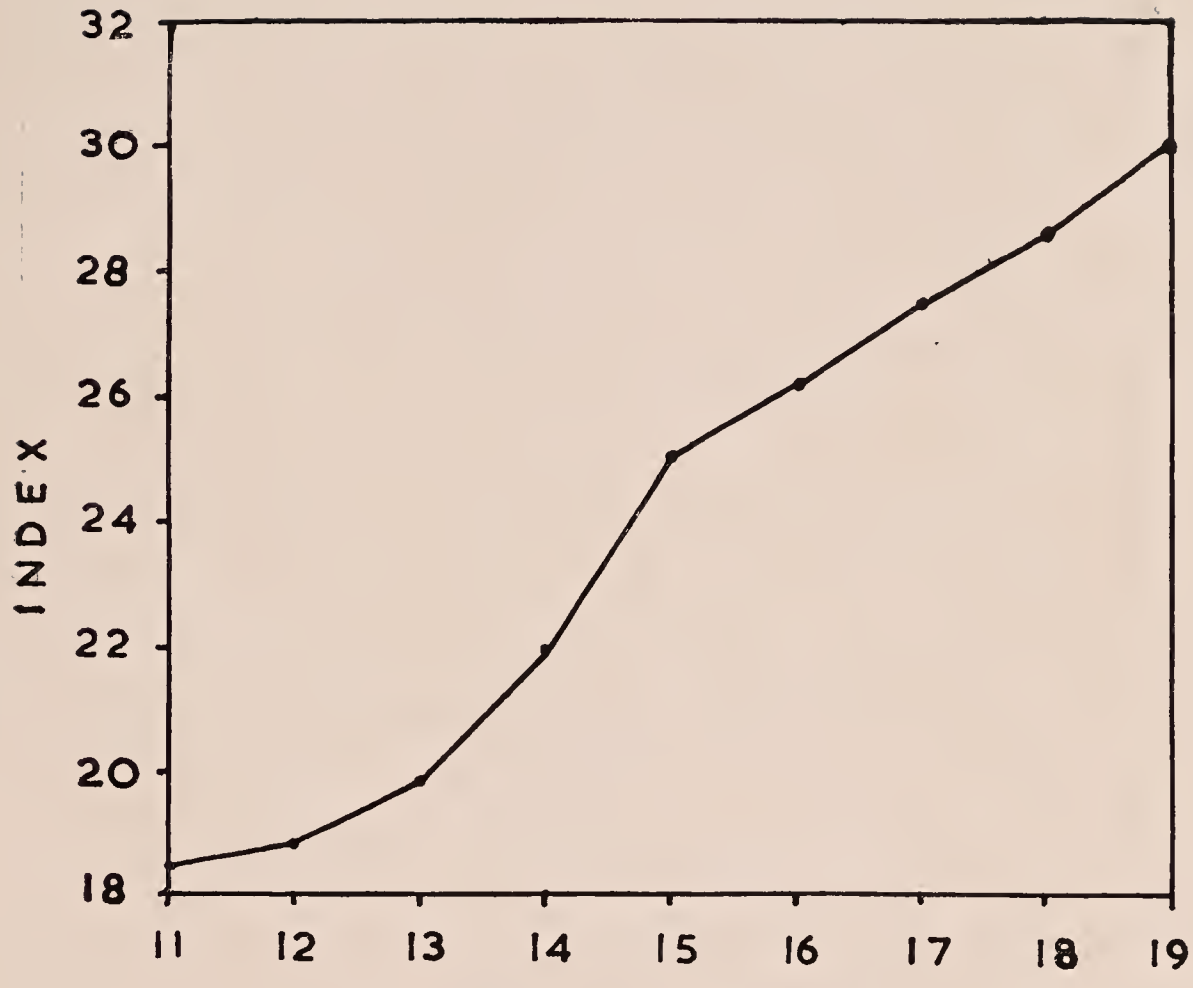

Fig. 32. Mean Curve of height weight Index.

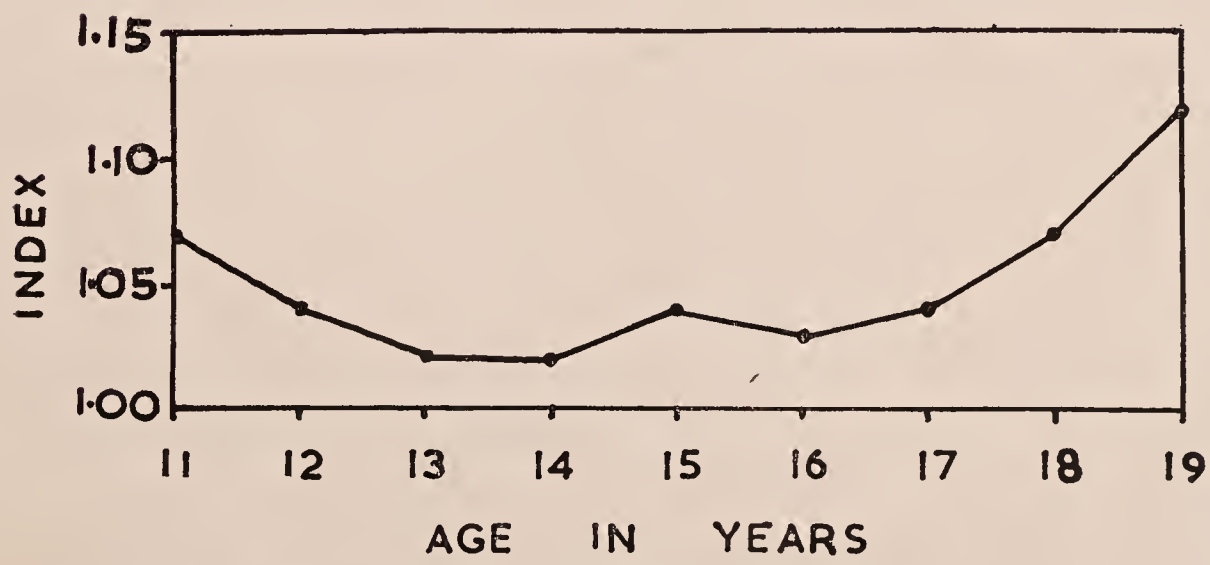

Fig. 33. Mean Curve of Rohrer's index.

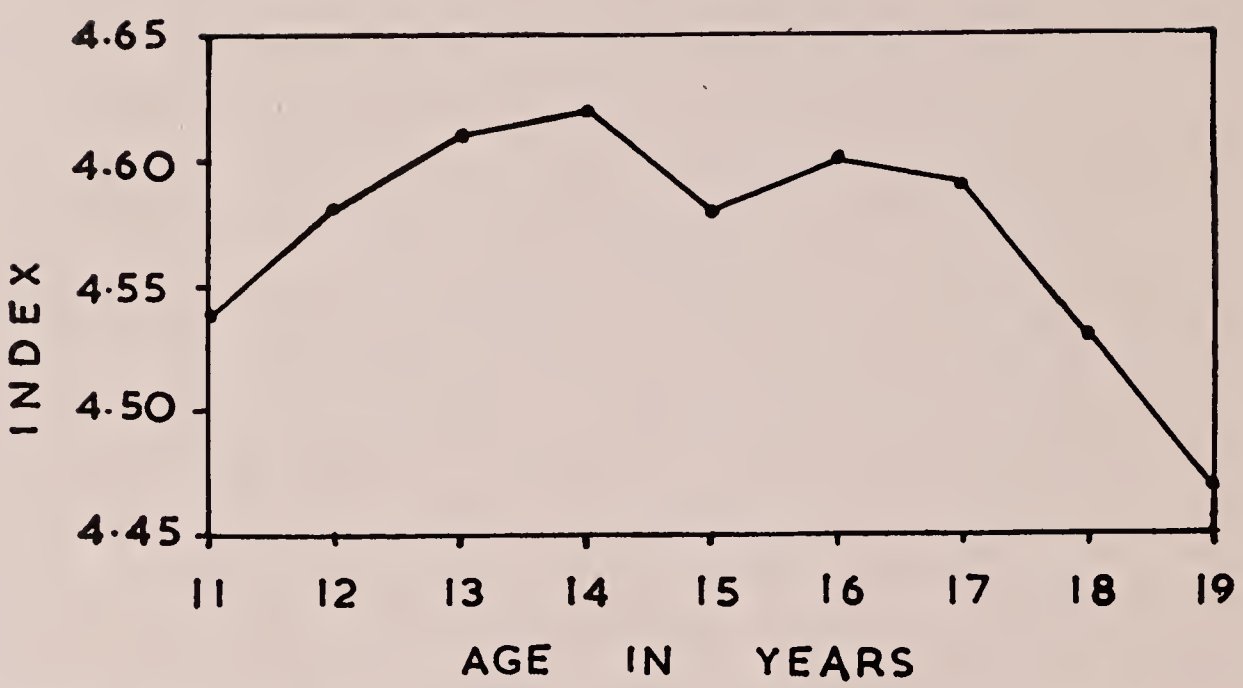

Fig. 34 · Mean Curve of Ponderal index.

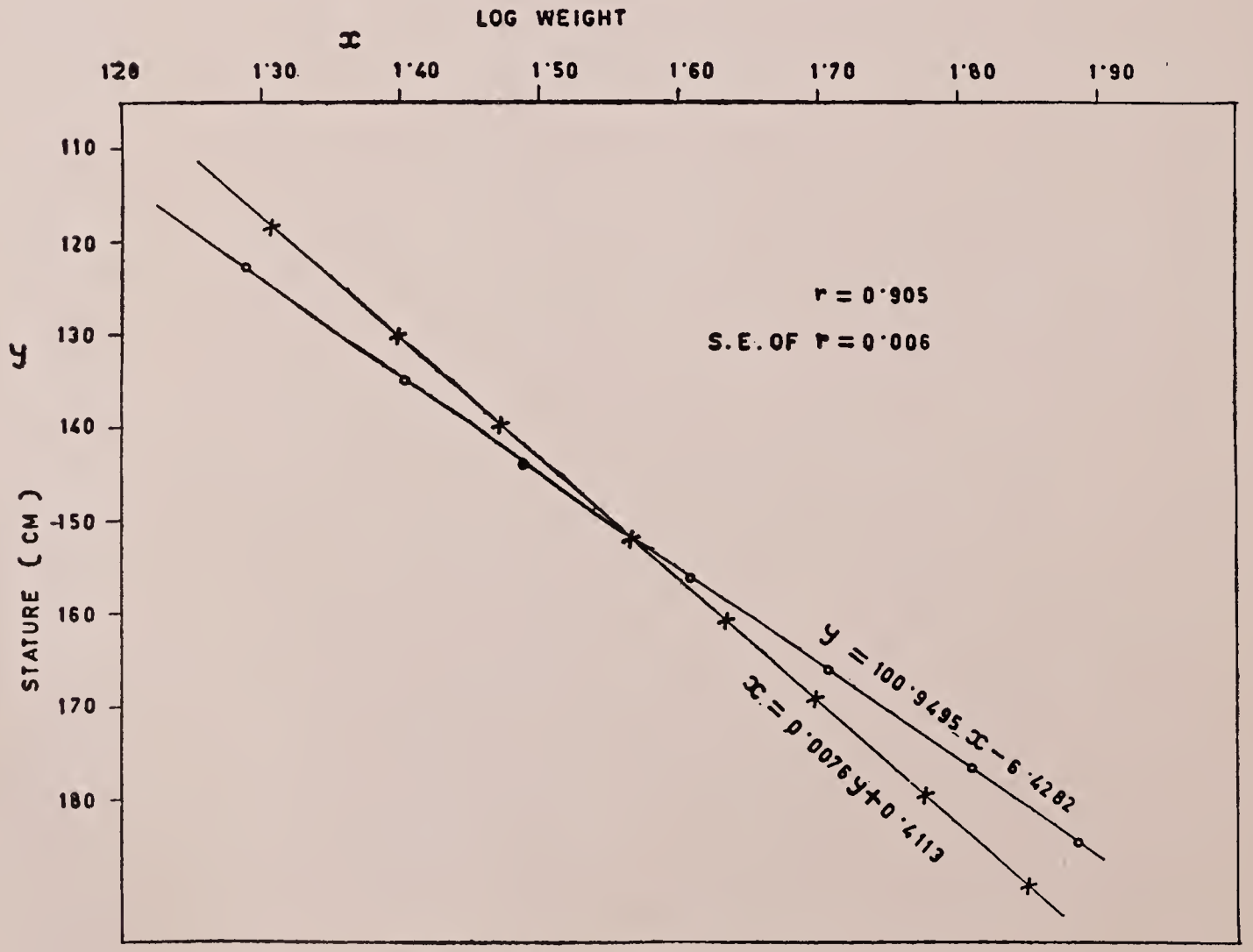

FIG. 35 REGRESSION LINES OF DATA FOR LOG WEIGHT / STATURE

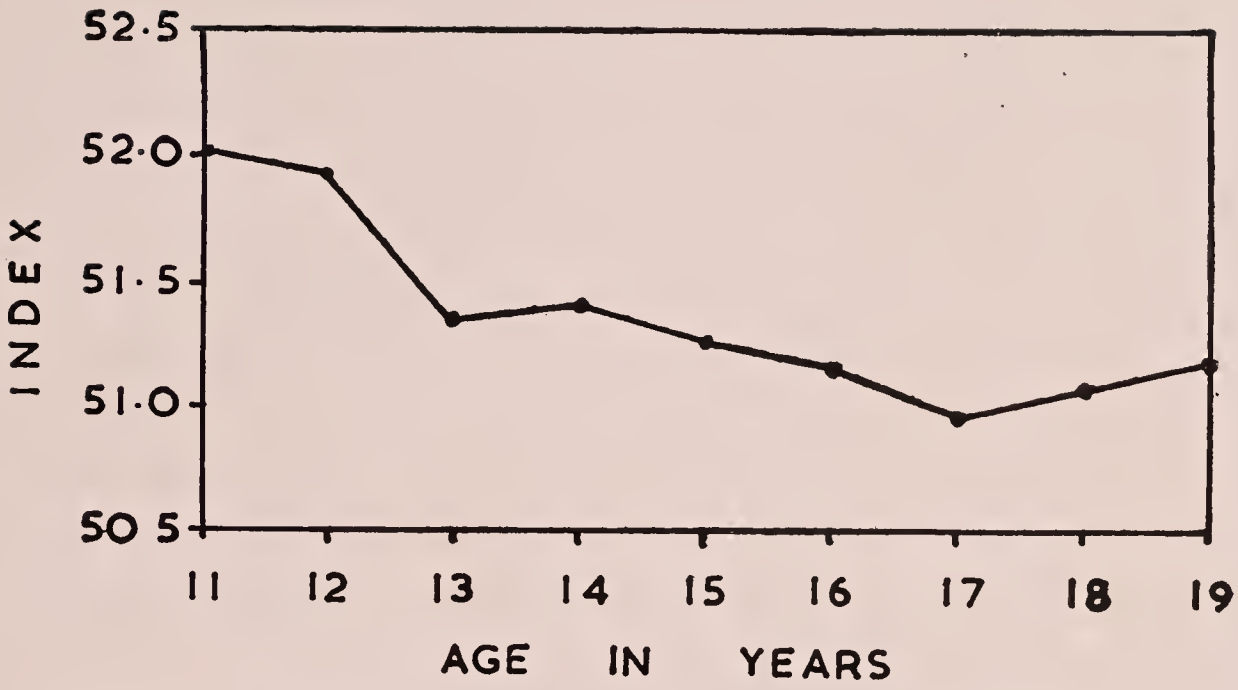

Fig.36 · Mean Curve of sitting height : Stature index.

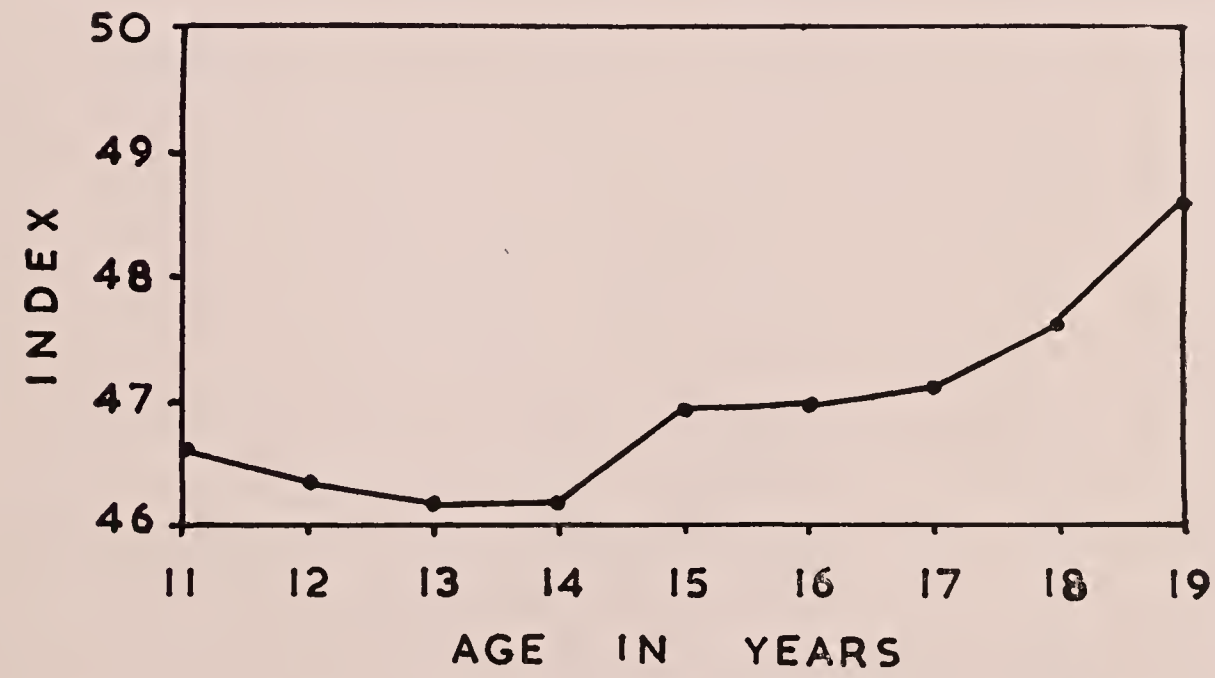

Fig. 37 · Mean Curve of Chest circumference: Stature index.

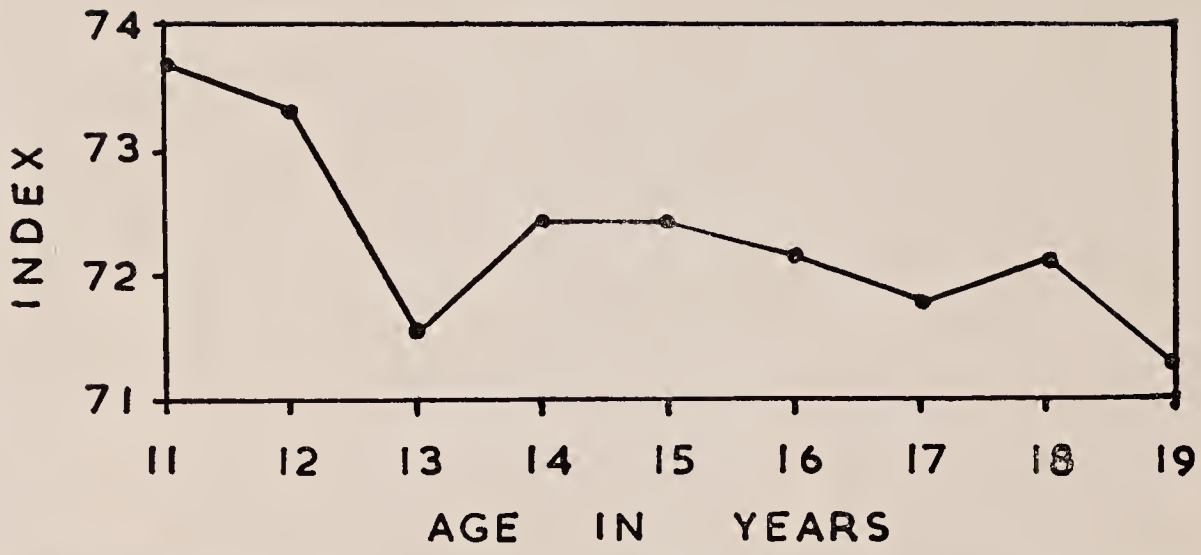

Fig. 38. Mean Curve of Chest depth : Chest breadth index.

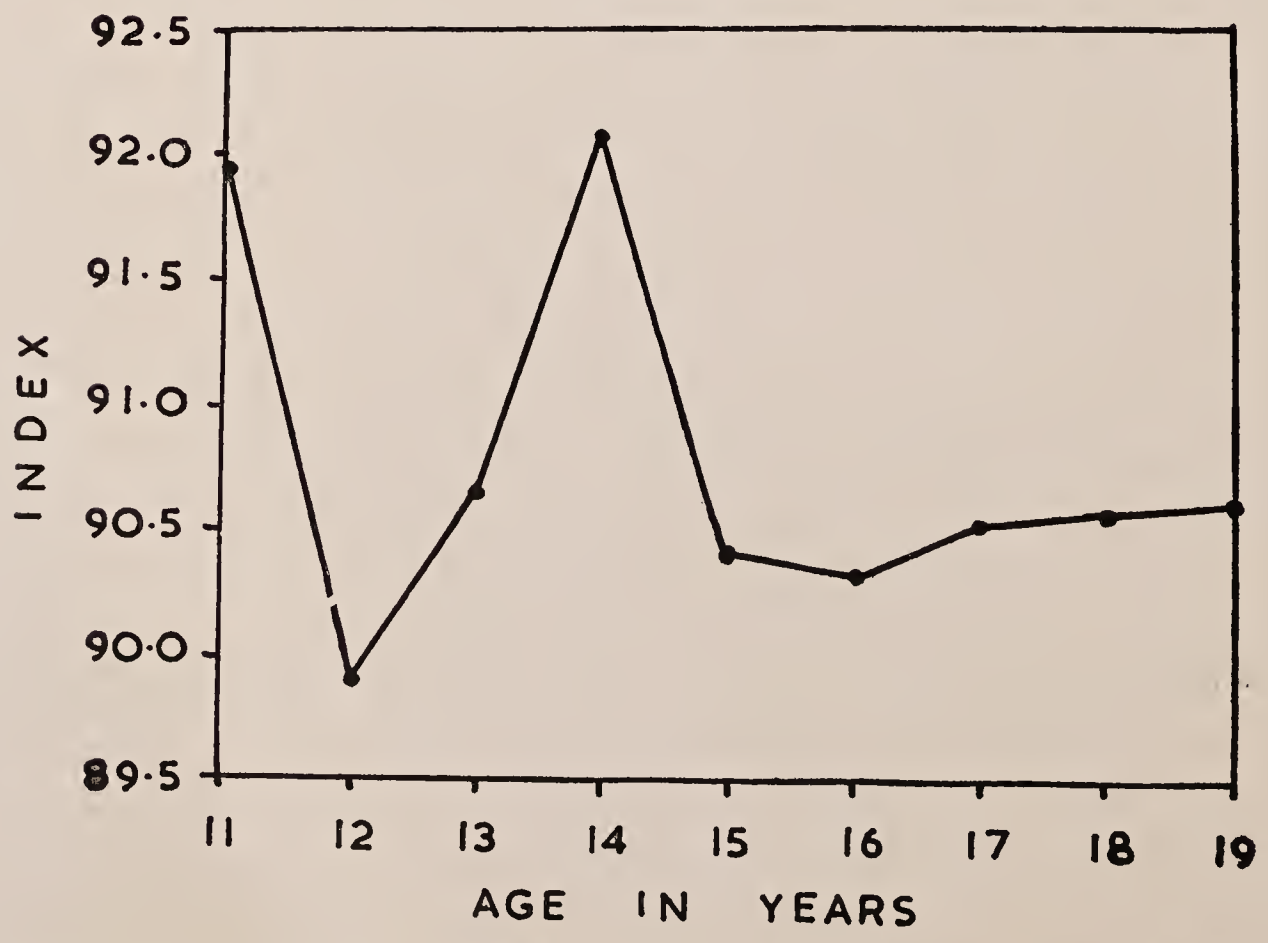

Fig. 39. Mean Curve of intermembral index.

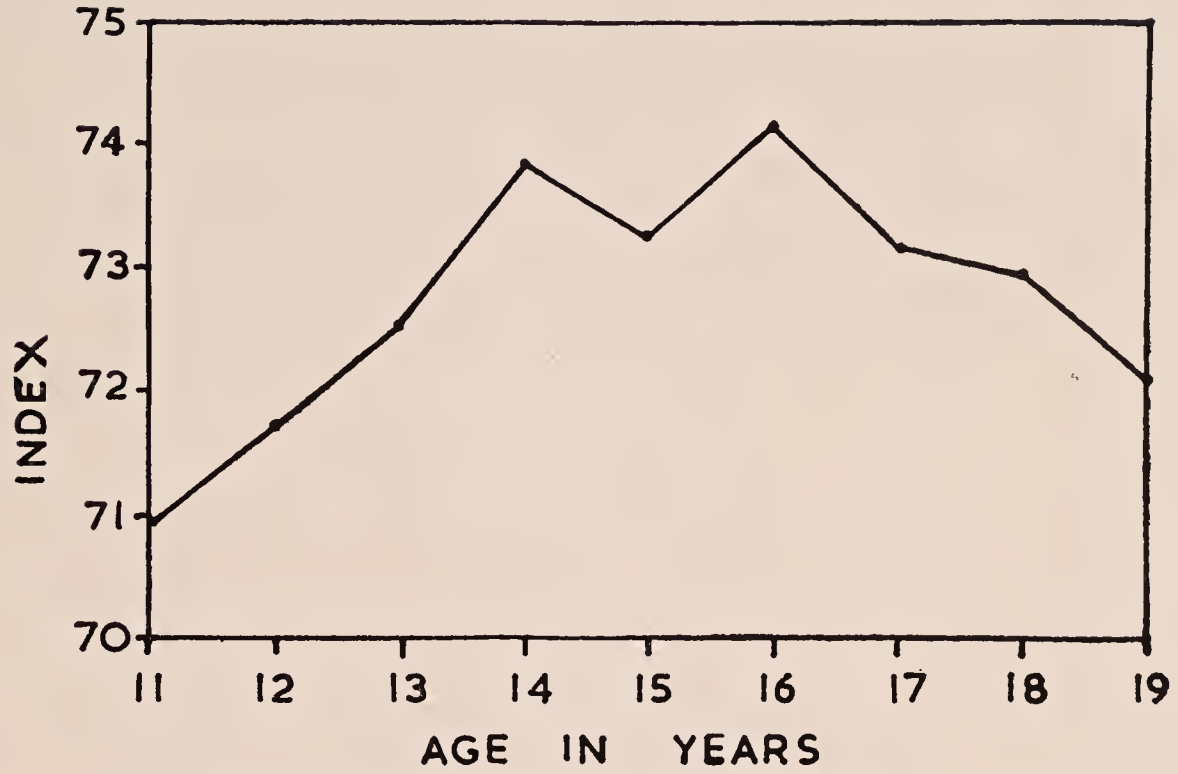

Fig. 40. Mean Curve of acromion : iliae index.

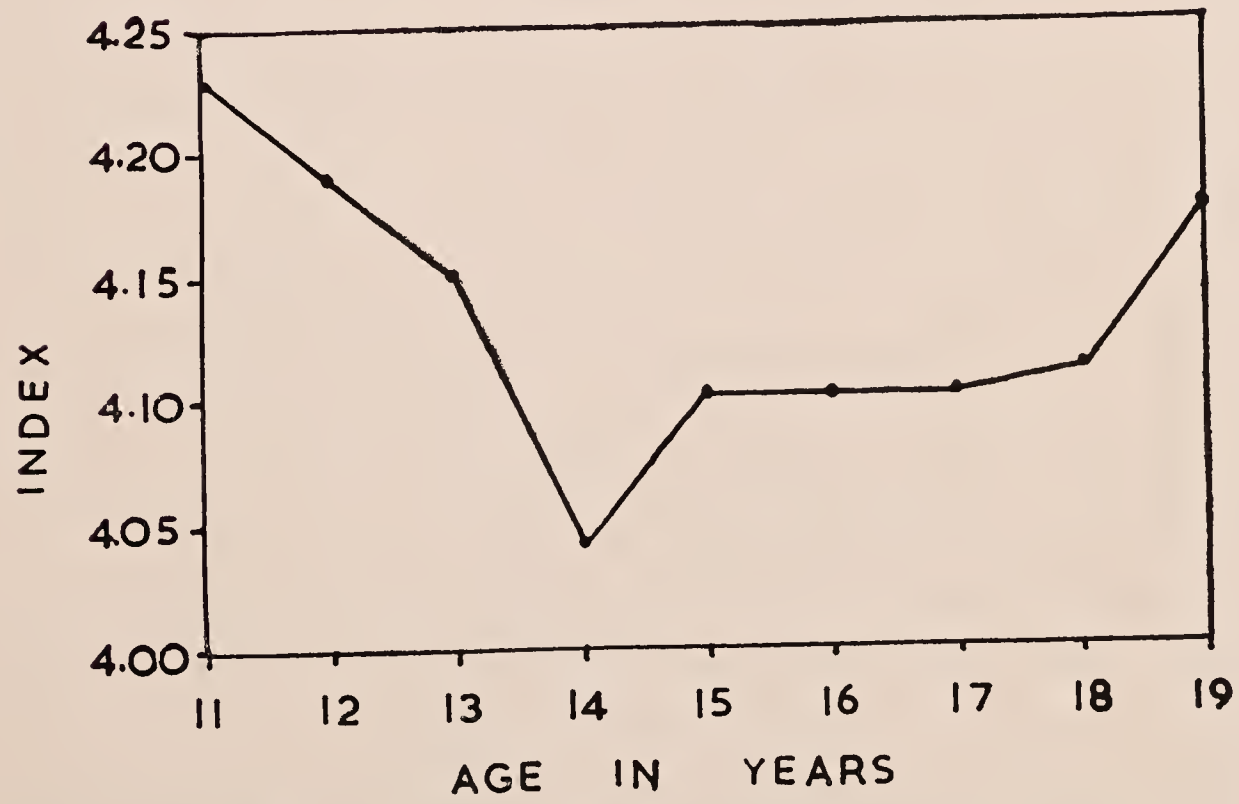

Fig. 41. Mean Curve of androgenity index.

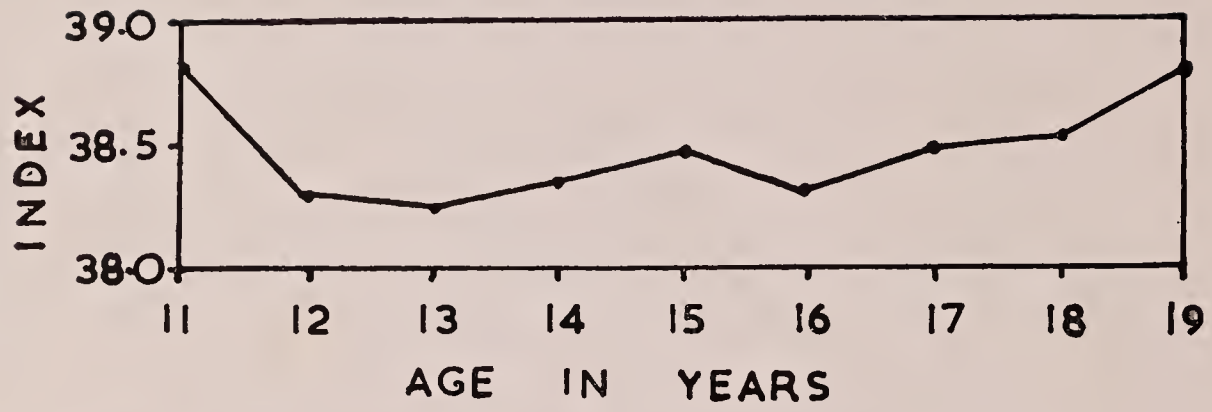

Fig. 42. Mean Curve of Calf girth : Chest circumference index.

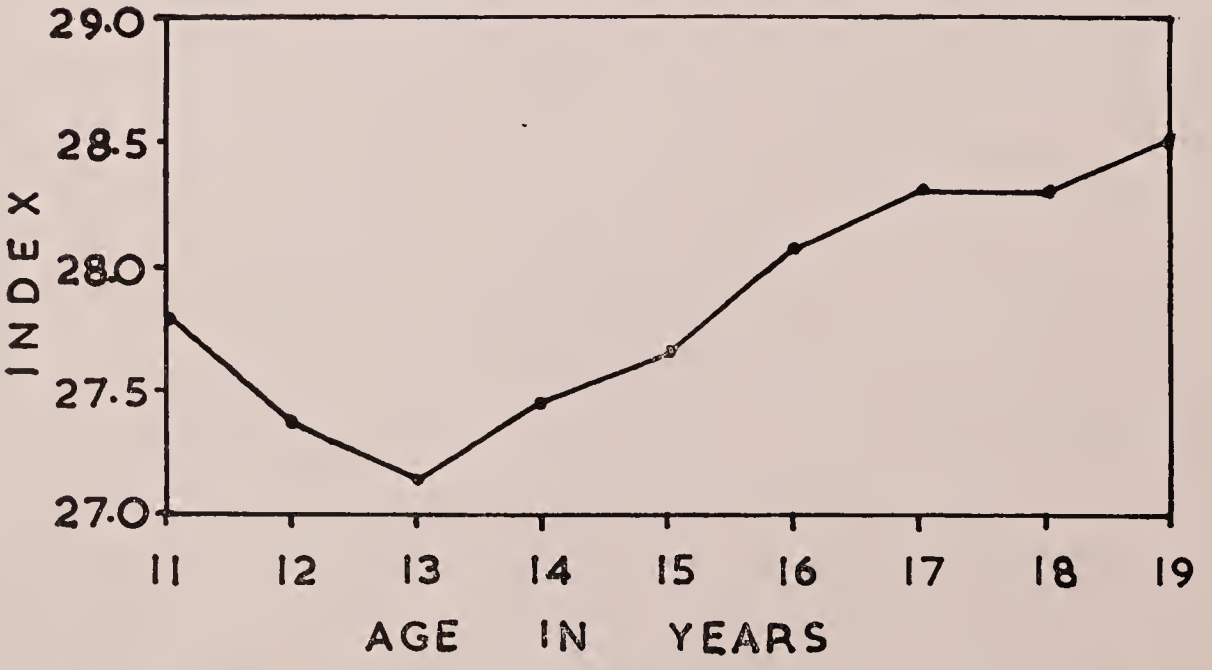

Fig. 43. Mean Curve of Upper arm girth: Chest circumference index.

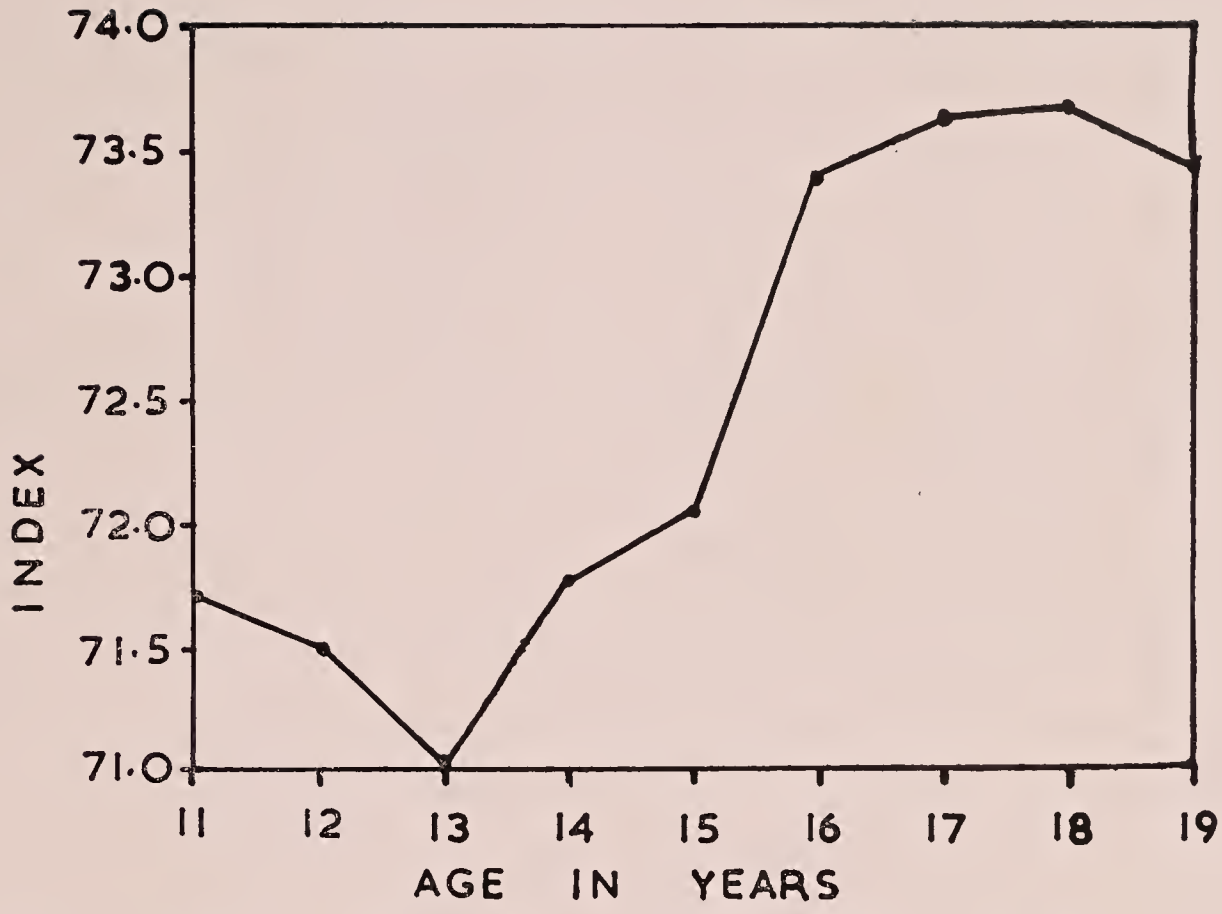

Fig. 44 · Mean Curve of upper arm girth: Calf girth index.

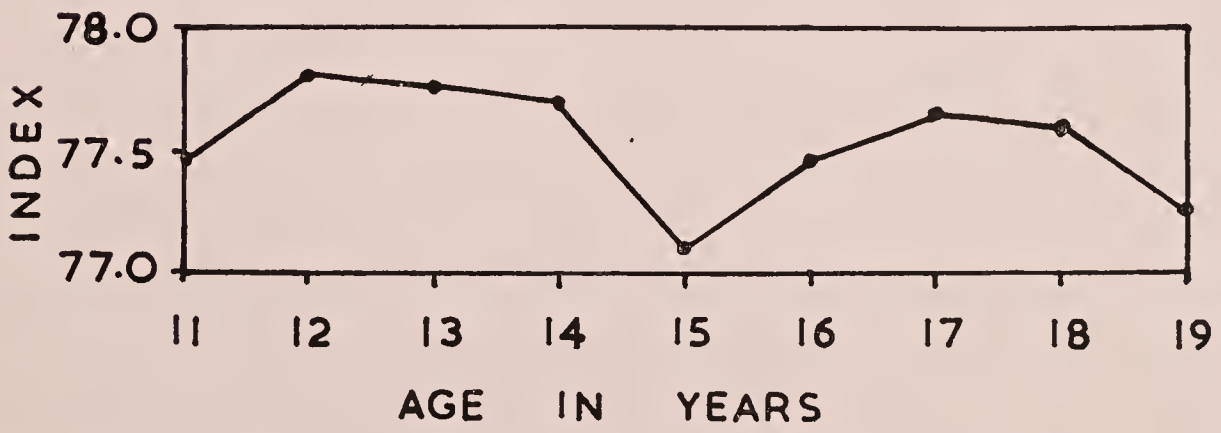

Fig. 45 · Mean Curve of Cephalic index.

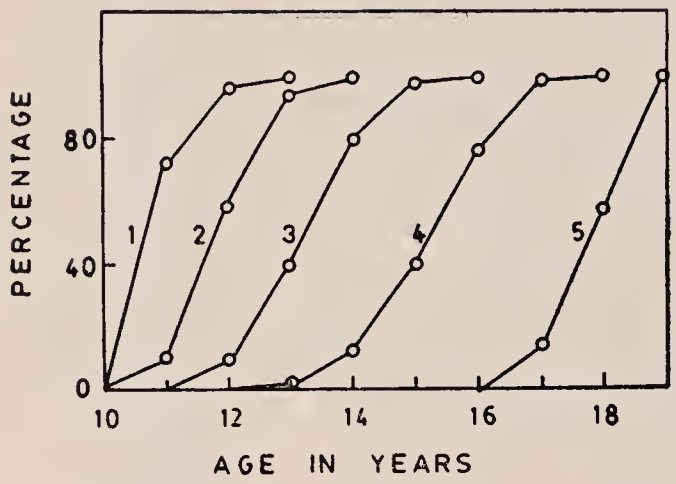

FIG.46 Cumulative percentage distri-
-bution for stages of genitalia
maturation

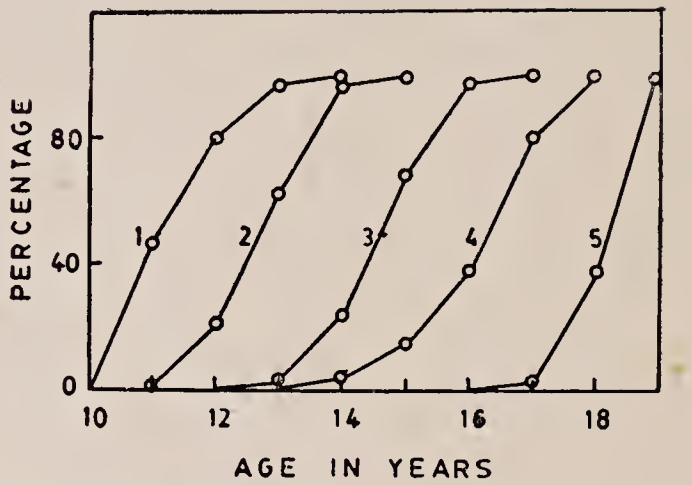

FIG.47 Cumulative perentage distribu-
-tion for stages of pub ic hair

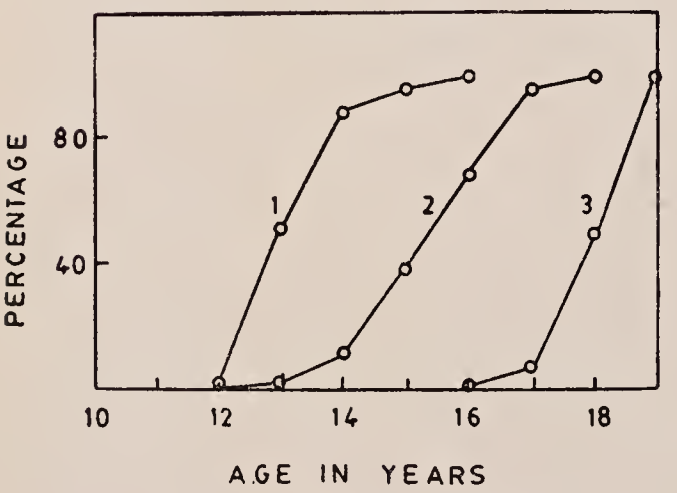

FIG.48 Cumulative percentage distri-
-bution for stages of facial
hair

FIG.49 Cumulative percentage distri-
-bution for stages of axillary
hair

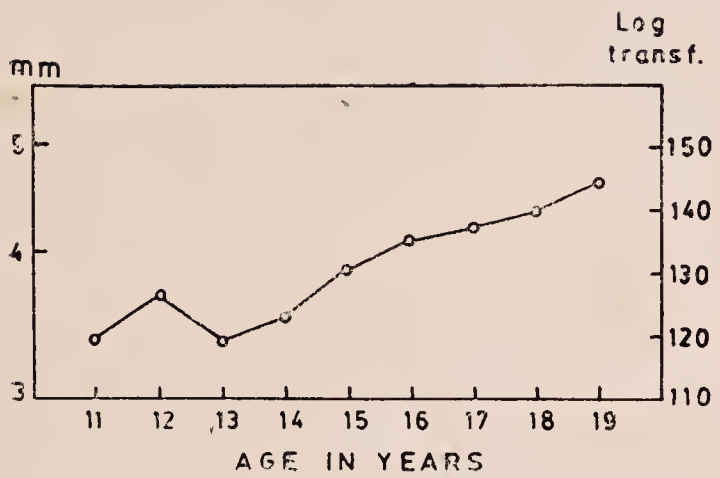

Fig. 50 Pattern of chage in the Biceps skilfold by age.

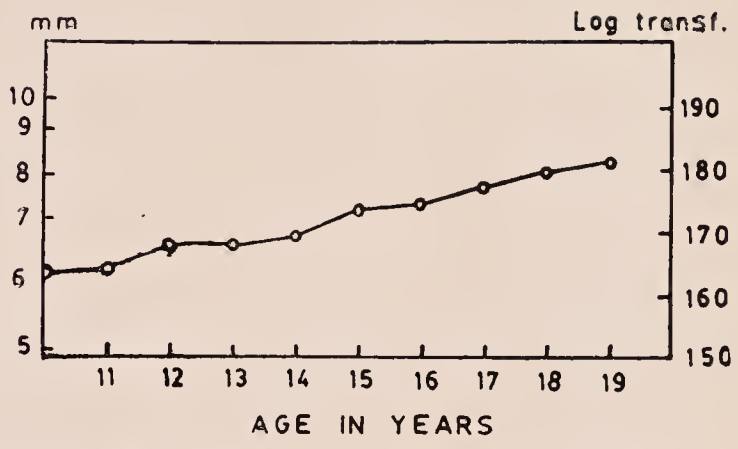

Fig. 51 Pattern of change in the Triceps skilfold by age.

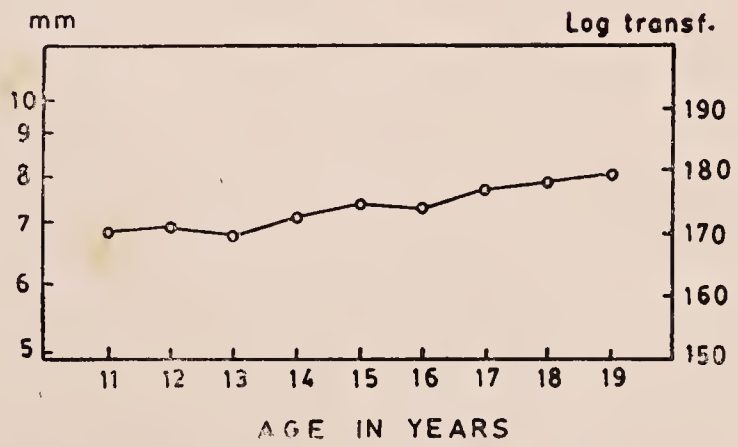

Fig. 52 Pattern of change in the subscapular skilfold by age.